REPORT RESUMES

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THE DEVELOPMENT OF A MOBILE LABORATORY FOR THE IN-SERVICE EDUCATION OF TEACHERS OF SCIENCE AND MATHEMATICS.

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TO IMPROVE THE ACADEMIC COMPETENCE OF SCIENCE AND MATHEMATICS TEACHERS, A MOBILE LABORATORY WAS DEVELOPED TO PROVIDE INSERVICE EDUCATION. CURRICULUM DEVELOPMENT PRECEDED THE LABORATORY DEVELOPMENT. THE MOBILE LABORATORY WAS PROVIDED WITH EQUIPMENT, APPARATUS, AND DISPLAYS. SCHOOLS WERE SELECTED AND DESIGNATED AS AN EXPERIMENTAL GROUP AND A REFERENCE GROUP. EVALUATIONS WERE MADE BY MEASURES INVOLVING TEACHERS, STUDENTS, SUPERVISORS, AND ADMINISTRATORS. IN GENERAL THE RESULTS INDICATED THAT THE TEACHERS IMPROVED ACADEMICALLY AND, TO A LESSER EXTENT PROFESSIONALLY. ALSO, THE TEACHING AIDS WERE FOUND TO BE MORE VALUABLE THAN THE LABORATORY AND DEMONSTRATION EQUIPMENT. FINALLY, PROGRESS WAS MADE IN ACHIEVING A CLOSER RELATIONSHIP BETWEEN MATHEMATICS AND SCIENCE IN THE CURRICULUM FOR THESE TEACHERS. THE IMPLICATIONS FOR FURTHER DEVELOPMENT WERE THAT A LONGER VEHICLE, NEARLY SELF-CONTAINED, WAS NEEDED AND THAT A GREATER NUMBER OF SPECIALISTS SHOULD PARTICIPATE. (RS)

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RF Project 945
Final Report

The Development of a Mobile Laboratory for the In-Service Education of Teachers of Science and Mathematics

by

John S. Richardson and T. Handley Diehl
Bureau of Educational Research and Service
The Ohio State University

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Office of Education
Washington 25, D.C.

The Ohio State University
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RF Project 945
Report No. Final

FINAL REPORT

By

THE OHIO STATE UNIVERSITY
RESEARCH FOUNDATION

1314 KINNEAR ROAD
COLUMBUS 12, OHIO

To: DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education
Washington 25, D. C.
Grant No. 733014.09

On: THE DEVELOPMENT OF A MOBILE LABORATORY FOR THE IN-SERVICE EDUCATION OF TEACHERS OF SCIENCE AND MATHEMATICS, FINAL REPORT

For the period: 1 June 1959 - 28 February 1961

Submitted by: John S. Richardson
Bureau of Educational Research and Service

Date: May 1961

FOREWORD

The idea of a Mobile Laboratory for science and mathematics teachers had its inception during the 1930 depression years. It was believed then, as now, that an effort should be made to determine the effectiveness of working with secondary school science and mathematics teachers in their teaching environment. However, a lack of funds has prevented attempting research of this type until the present time.

The past two decades have intensified the need to make every effort to improve the teaching of science and mathematics in our secondary schools. The factors bearing on this critical problem are well known; they point to the necessity of helping teachers in their own school environments. The complexity of the situation requires that every effort be made to increase our effectiveness in preparing teachers and in providing in-service education for them. With the advent of the National Defense Education Act it became possible to make an initial attempt to work directly with the teachers.

The research project described in this report was supported primarily by a grant from the U. S. Office of Education. The Battelle Memorial Institute and The Ohio State University made smaller but significant contributions. Also, the project could not have been conducted without the wholehearted cooperation of the participating schools and their staffs.

It is impossible to acknowledge properly the efforts of the many persons who contributed to the success of the project. One of the most readily identifiable persons is Dr. Bert Thomas, President of the Battelle Memorial Institute. Through his efforts the grant from the Institute was made available at a point when the activation of the project was in jeopardy. This fund made possible the purchase of apparatus and supplies highly essential to the research.

The assistance of many members of the faculty of The Ohio State University is acknowledged with appreciation. Special mention should be made of Professors Harold Fawcett, Ross Mooney, Edgar Dale, and Egon Guba. The advice of Dr. Richard Hull and the continuing assistance of Mr. Harold Gorsuch, as well as others on the staff of WOSU-TV, has been greatly appreciated. The counsel of the various members of the University Committee for Title VII Projects was valued in the planning of the study. Mr. Handley Diehl drew upon his extensive experience to implement the design of the project and to manage the immediate details of its organization and of the instructional program.

Most recently, and in many respects most importantly, the work of Professor Fred Schlessinger and of Mrs. Walter Brown brought the report to a successful conclusion. The work of all these persons and of many others not named here has been deeply appreciated.

John S. Richardson
Director

TABLE OF CONTENTS

Page

I. PURPOSE OF THE PROJECT 1

II. RATIONALE OF THE RESEARCH 1

III. PERSONNEL FOR THE STUDY 2

IV. DEVELOPMENT OF THE CURRICULUM 4

A. Academic Components of the Curriculum 4

B. Professional Components of the Curriculum 5

C. Teaching Procedures and Materials 6

V. DEVELOPMENT OF THE MOBILE LABORATORY 8

A. Equipment and Apparatus 9

B. Display of Equipment, Professional Literature, and Reference Materials 9

VI. SELECTION OF THE SCHOOLS 10

A. Willingness to Participate 10

B. Reference and Experimental Schools 12

C. The Participating Schools 12

VII. PLANNING WITH THE SCHOOLS 14

VIII. PLAN OF EVALUATION 15

A. Evaluative Measures Involving Teachers 15

B. Evaluative Measures Involving Students 19

C. Evaluative Measures Involving Supervisors 20

D. Evaluative Measures Involving Administrators 20

IX. PLAN AND SCHEDULE FOR THE PROGRAM PRESENTATION 21

A. Outline of the Program 21

B. Schedule for the Activities of One Day 29

X. VISITS TO THE REFERENCE SCHOOLS 30

CONTENTS (CONT'D)

Page

XI. EVIDENCE OBTAINED FOR EVALUATION 30

A. Analysis of Results from Evaluation Instruments 30

B. Evaluations by Administrators in the Experimental Schools 38

C. Synthesis of Informal Evaluations by Teachers in the Experimental Schools 42

D. Miscellaneous Evaluative Reactions and Suggestions 45

XII. SUMMARY AND CONCLUSIONS 48

APPENDICES

A. SCHEDULE A-1

B. LIBRARY OF THE MOBILE LABORATORY B-1

C. APPARATUS AND SUPPLIES C-1

D. AUDIO-VISUAL RESOURCES D-1

E. EVALUATION INSTRUMENTS E-1

F. STATISTICAL INFORMATION AND OTHER EVIDENCE F-1

G. LABORATORY EXPERIMENTS AND DEMONSTRATIONS FOR HIGH SCHOOL STUDENTS G-1

H. PLAN OF MOBILE LABORATORY H-1

I. PURPOSE OF THE PROJECT

The improvement of the competence of teachers of science and mathematics requires that their academic background be strengthened and that their professional competence be increased. The purpose of this research project was to develop a mobile laboratory for science and mathematics teachers, and to determine its effectiveness in the improvement of science and mathematics teaching in the secondary schools through its use with the teachers in these fields.

Specifically, the objectives were the following:

1. To produce and develop a Mobile Laboratory for the use of science and mathematics teachers in the improvement of their academic and professional competence.

2. To develop procedures and techniques for the use of a mobile laboratory for science and mathematics teachers.

3. To determine the effectiveness of the instructional media in such a mobile laboratory.

4. To study the use of several media and devices in a situation designed to cause each such medium or device to be part of a total presentation. Media and devices included such things as motion pictures, television, demonstrations, models, reading materials, commercial and hand-made apparatus and the like. In this presentation, the object was to make the contribution of each medium or device relate to or be complementary to the contributions of the other resources included in the mobile laboratory.

5. To bring the presentations of science and mathematics in the mobile laboratory together in such ways as to teach the interrelationships of the academic areas included.

II. RATIONALE OF THE RESEARCH

Many efforts are currently under way to improve the academic competence of science and mathematics teachers. There is little question that this attention is needed, and the evidence seems to indicate that certain of the efforts to remedy the situation have been, at least in part, successful.

Some questions can be raised, however, as to whether the professional competence of these teachers is being neglected. While presumably the certificated teacher is professionally competent at the time of certification, professional knowledge grows old just as does academic knowledge. Furthermore, there is good reason to hypothesize that the improvement of academic competence and professional competence should be accomplished simultaneously, i.e., within the same functional setting of learning.

The many efforts to improve the competence of science and mathematics teachers almost necessarily remove the teachers from their own teaching situations. This is true primarily of the programs aimed at the improvement of academic competence, but it is also somewhat true of those programs limited to the improvement of professional competence. The large scale of the effort necessary to meet our national needs has made imperative the use of large-group instruction. But the assembly of large groups of science and mathematics teachers necessarily removes most or all of them from the working situation in which their improved competence is to be manifested. Too often the knowledge gained on a university campus during a summer session or at a week-end conference has lost much of its luster and promise by the time the teacher has arrived back in his classroom at some distant point.

The use of a mobile laboratory provided an opportunity to bring together the foregoing elements: new as well as familiar media of instruction to upgrade professional competence; opportunities for professional and academic growth in a common setting for learning; and the provision for such professional and academic growth in the familiar and functional setting of the teacher's own school.

III. PERSONNEL FOR THE STUDY

Many persons were associated with and made contributions to the study. Among those most actively involved were the following:

Director: John S. Richardson, Professor of Science Education. Dr. Richardson has directed research on science teaching facilities, evaluation, and science teacher education. He has contributed to many institute programs and directs the Academic Year Institute at The Ohio State University. He is the author of Science Teaching in Secondary Schools, and a past president of the National Science Teachers Association.

Associate Director: T. Handley Diehl. Mr. Diehl has a record of very successful teaching of science and mathematics in the high schools of western Ohio, his most recent experience being in the Cincinnati Public Schools. In June of 1959 he was appointed to the staff as Research Associate in the Bureau of Educational Research and Service of the Ohio State University.

Research Advisers:

Professors Ross Mooney and Egon Guba of the Bureau of Educational Research and Service advised in the design of the research proposal submitted to the U. S. Office of Education.

Professor William R. Flesher of the Bureau of Educational Research and Service, and Professor Franklin Knover of the Department of Speech, were the principal consultants in the design and execution of the evaluation instruments and procedures. Dr. Flesher assisted also in the selection of the schools that participated in the study.

Scientific Consultants: The following persons assisted in the development of the curriculum in science and mathematics presented to the teachers:

Professor Robert Fisher, Department of Mathematics

Professor Alfred Garrett, Department of Chemistry

Professor James G. Haub, Department of Zoology

Professor Willard Myser, Department of Zoology

Professor William R. Riley, Department of Physics.

Professional Consultants: The following persons assisted in the development of the professional curriculum presented:

Professor Harold P. Fawcett, Department of Education

Professor John S. Richardson, Department of Education

Professor Fred R. Schlessinger, Department of Education

Mr. Irvin L. Sleesnick, Department of University Schools.

Teaching Personnel: The following persons participated in the teaching program, either directly or through kinescopes:

Mr. T. Handley Diehl, Bureau of Educational Research and Service

Professor Harold P. Fawcett, Department of Education

Professor David Miller, Department of Zoology

Professor Melvin Newman, Department of Chemistry

Professor Harald Nielsen, Department of Physics

Professor K. Narahari Rao, Department of Physics

Professor John S. Richardson, Department of Education

Professor Fred R. Schlessinger, Department of Education

Mr. Irwin L. Slesnick, Department of University Schools.

Technical Personnel: The following persons helped to design and equip the mobile laboratory and to service and maintain it while in use:

Mr. Jack Daniels, Bureau of Educational Research and Service

Mr. Harold Gorsuch, Telecommunications Center

Mr. William Walters, Bureau of Educational Research and Service.

IV. DEVELOPMENT OF THE CURRICULUM

The units of study were selected to include six areas; these were mathematics, physics, chemistry, biology, radioactivity, and professional education. Consultants were selected to represent each of those subject areas, and their advice was sought to determine a feasible program for each area. A suitable program was initiated so that the participating teachers would benefit from all areas as well as from their particular academic interest. The selection of the content was such that the information was on a level of comprehension commensurate with the assumed general background of the participants. A criterion of selection of content was that the academic material included could be interrelated throughout the areas suggested above.

The academic phase of the curriculum in science and mathematics was designed so that its components were selected and integrated with a view to the needs and projected uses of the teachers affected. With the limitations of a ten-day period of teaching in each school in view, the following paragraphs suggest the interrelations of the academic components as presented in person and through closed-circuit television by the Associate Director and the Consultant in Mathematics Education, and by other teaching personnel through motion pictures and kinescopes.

A. ACADEMIC COMPONENTS OF THE CURRICULUM

The mathematics included was presented from the standpoint of vectors and probability. Vectors were related to the nature of light and such phenomena as polarization, while probability was related to radioactive counting and decay. Developments in modern mathematics curriculum were presented in one session at most schools by the Consulatant in Mathematics Education.

The molecule and its motions were related to the Newton Laws of Motion with the indication that the laws of motion hold true regardless of the size of the body. Concepts of the methods of measurement using light and the definition of certain properties of the molecules were used to explain the basic ideas underlying chemical reactions.

Certain concepts in biology were included, such as those of excited atoms and molecules with the transfer of energy in chlorophyll. Suggestions were made for demonstration in this area, and demonstrations were performed to indicate what can be done to illustrate these concepts to the high school student.

In the area of radioactivity, the uses of radioactive elements were indicated as possible techniques to be employed in the development of ideas concerning the life processes in biology. Health problems resulting from radiological developments were included.

B. PROFESSIONAL COMPONENTS OF THE CURRICULUM

The professional contributions of the mobile laboratory were intended to be intimately related to the academic components as previously discussed. These contributions were planned through the following activities:

1. The selection of content for the curriculum units of the mobile laboratory.
2. The provision of laboratory time for instruction.
3. The method of the demonstrations presented.
4. The method of television presentations and the unique use of television.
5. The display and use of new, functional commercial apparatus.
6. The display and use of hand-made apparatus.
7. Display of professional literature and teaching materials.
    a. Services of professional associations.
    b. Books, pamphlets, filmstrips, charts, magazines.
8. Presentation of a kinescope on the use of the laboratory in science teaching.
9. Presentation of films from the Physical Science Study Committee and films from the Department of Zoology.

10. Classroom work of Assistant Director.

11. Participation of classroom teachers in television program production and in other creative activities.

12. The use of a system for inventorying apparatus and materials.

An elaboration of each of the foregoing contributions is essential to an understanding of the curriculum. The first of the contributions listed - the selection of content for the curriculum of the mobile laboratory - has already been presented on page 4. The remaining types of contributions cited are described briefly below.

C. TEACHING PROCEDURES AND MATERIALS

Kinescopes and Motion Pictures. One of the experimental elements of the study centered around the hypothesis that high school science and mathematics teachers will profit by a university campus - high school relationship in which scientific and professional endeavors from the campus are brought directly to the high school teachers. One means of testing this hypothesis lay in the production of kinescopes and motion pictures of campus research and teaching activities to be shown to the teachers as a part of the mobile laboratory instruction.

Original plans called for films to be developed in chemistry, physics, biology, education, and mathematics. Because of the time factor, it was possible to complete only three kinescopes, one each in chemistry, physics, and education. In the kinescope produced by the Department of Chemistry, Professor Newman presented a lecture on the factors influencing chemical reactions. The kinescope in physics was produced through the combined efforts of Dr. Rao, Dr. Nielsen, and Dr. Riley. This film explained the field of infrared research and was produced in the laboratory of the Department of Physics. The third kinescope was devoted to the effective use of the laboratory in science teaching. Professor Schlessinger, Mr. Slesnick, and students from the University School made the presentation. Because these films were developed expressly for the curriculum, they were integral parts of the presentation.

Two motion picture films were borrowed from the Department of Zoology. These films had been produced earlier to present certain aspects of research in that department. These were entitled "The Life Cycle of the Frog" and "The Male Frog Pregnancy Test." Two other motion pictures prepared for the physics program designed by the Physical Science Study Committee were included in the presentations because of their relevance to the objectives served by the curriculum. The first of these films, "Measuring Short Distances," was concerned with the ion microscope; the second, "The Millikan Experiment," depicted the measurement of charges on particles. All of the films used for this approach to the teacher were recommended by the various consultants.

The Use of Television. The television medium was used to a considerable extent throughout many of the programs. Studio facilities were usually set up on the stage of the participating school. This necessitated parking the mobile laboratory as close to the auditorium as was physically possible.

The video and audio information was carried to a near-by classroom, auditorium, teachers' lounge, or, in one case, an administrator's office. A portion of the first lecture was devoted to orientation with a direct presentation to the participating teachers. The research program was explained to them in conjunction with an inspection of the complete facilities which would be at their disposal during the visitation of the mobile laboratory. Each group of teachers was encouraged to make use of the equipment available to their best advantage. For the first several days the television was used for the presentation of the lectures. The program was composed of two such 45-minute lectures followed by a laboratory period of one to one and one-half hours. The television was thus utilized for approximately one and one-half hours each day. On the eighth day motion pictures and slides were projected through the television medium; however, the lecture was given personally to the teachers. On the ninth day Dr. Harold P. Fawcett presented in person concepts of modern mathematics and of mathematics teaching to the participating teachers of the experimental schools. On the tenth day the mobile laboratory was in the process of being moved to a new location and television was not used. The last session included lectures and discussions directly with the teachers.

Teachers were encouraged to experiment with the medium of television in their own teaching. It was suggested that they prepare a lesson and rehearse it before the cameras. They could then present the lesson through television to their own students. A few of the teachers took advantage of this opportunity.

Laboratory Time for Instruction. The laboratory periods were designed to supplement the more formal presentations of academic content. It was expected that the lecture demonstrations would take on new meaning because of the laboratory work. Usually the first laboratory period used the problem of vectors from the first presentation. This problem gave an opportunity for the teachers to utilize the individual chalkboards and magnetic tape arrows. Another laboratory period provided the teachers an opportunity to measure the wavelength of light. Another permitted them to measure the half-life of radioactive dust in the atmosphere. Each of these laboratory experiments then was designed to portray the basic ideas of the curriculum. Copies of the laboratory experiments were provided as references for the participating teachers. Some of the experiments used were taken from The Science Teacher. Other reference materials of this kind were also available.

Quality of the Demonstrations Presented. The criteria used in selecting and preparing demonstrations for the mobile laboratory curriculum were the following:

1. The practicability of future demonstrations to be used by the teachers.

2. The feasibility of packing and transporting materials in the mobile laboratory.

3. Space and cost requirements for the schools.

4. The feasibility of using homemade materials in demonstrations.

5. Organization and presentation of the demonstration in such a way that it would seem feasible for use by the usual science teacher.

Since many of these programs were produced by television, smaller demonstration equipment was utilized than would have been necessary if personal lecture-demonstrations had been given throughout the experiment. The beginning demonstration gave techniques in the use of materials, while later demonstrations informed the participating teachers of materials they could purchase or prepare with the aid of their industrial arts facilities. Still another phase of the demonstration program dealt directly with scientific and mathematical information which would aid them in their teaching responsibility within their particular classroom. The demonstrations for this phase of the program were a means to an end rather than an end in themselves. There was a constant effort to encourage teachers to use the materials that were available during the mobile laboratory visitation. Such demonstrations did encourage some teachers in each school to take advantage of these resources as noted later.

Display and Use of Functional Apparatus. An attempt was made to obtain the newest commercial apparatus that was available from scientific manufacturers. Equipment that could be used for more than one purpose was obtained in an effort to assist the school in capitalizing upon its investment. Those materials which may not have been directly involved in demonstrations were placed on display in the mobile unit, so that the participating teachers might evaluate the materials and discuss the problems of their usage with the mobile laboratory personnel. Suggestions were made as to materials that might be purchased for the individual classroom. The display included a considerable quantity of handmade apparatus which had been prepared especially for the mobile laboratory.

V. DEVELOPMENT OF THE MOBILE LABORATORY

Considered from a tactical standpoint the mobile laboratory should combine the potential for teaching both science and science education, and mathematics and mathematics education; it should include liberal teaching resources for both; it should provide for both familiar and new media of instruction; and it should be reasonably flexible in use and relatively mobile. The basic vehicle was provided by the University Administration. This vehicle was a 32-passenger school bus from which the seats had been removed. Into the space thus freed the various teaching resources were placed.

A. EQUIPMENT AND APPARATUS

1. Closed-Circuit television. Within the bus was located permanently the electronic equipment, such as amplifiers, film chain, slide projector, control panels, and monitors for the unit. The television cameras and a receiver were transported in the bus and removed to the appropriate locations in each school. The necessary cables for electrical power and signal communication were also transported in the bus.

2. Apparatus and supplies. Shelves and cabinets built into the bus provided storage space for the apparatus and supplies. A list of these resources is provided in Appendix C.

3. Audio-visual materials. Filmstrips, motion picture films, kinescopes, charts, and models were stored in the shelves and cabinets of the bus. A list of these materials is provided in Appendix D.

4. Books and other printed materials. Printed materials of both professional and scientific nature were stored in the cabinets of the bus. A list of these materials is provided in Appendix B.

5. Contrived apparatus. This included individual chalkboards, a movable chalkboard - display board unit, a movable demonstration table, and a set of cards for inventory. These units of contrived apparatus along with certain accessories are described in Appendix H.

B. DISPLAY OF EQUIPMENT, PROFESSIONAL LITERATURE, AND REFERENCE MATERIALS

The rear half of the mobile laboratory was arranged for storage while traveling and for display purposes while stationed at each school. The area consisted of a counter and two shelves on each side of the unit which were readily converted from storage into a display area. The shelves were provided with removable slide doors. These were removed for display purposes and installed for storage while traveling.

Materials which might be borrowed by the teachers for use in their own programs were set up attractively to encourage their use and to promote rapid inspection of the facilities. The hypothesis was that this display would encourage the use and acquisition of the materials. A shelf space of approximately eight linear feet was devoted to the presentation of materials. Other apparatus and teaching materials were presented to the teachers during the lecture periods and during the scheduled laboratory period.

Included with the materials in the display area of the mobile laboratory was a small library of professional and scientific books. The books had been recommended by the various consultants in the subject fields and from professional education.

Teachers were taken on an initial tour of the mobile laboratory facilities during the first meeting to acquaint them with the various services made available to them. At this time they were encouraged to revisit the laboratory during their available time in the school day. The apparatus and other teaching materials were used during the laboratory period of the scheduled meeting time each day.

VI. SELECTION OF THE SCHOOLS

A. WILLINGNESS TO PARTICIPATE

The basic condition for participation in the research study was the willingness of the school to do its necessary part. After the application of the factors listed and elaborated below, the invitations to the schools were extended. Thirty schools were invited in order to obtain the full roster of experimental and reference schools shown on pages 12 and 13. The principal basis for declining the invitation to participate seemed to be the unwillingness of the school administration to release teachers from obligations within the school day. As elaborated below, two reasonably equivalent groups of schools, the one experimental and the other reference, were chosen.

To assure a representative sampling of the schools to be involved in the research study the following factors were observed:

1. Geographic-economic areas.
2. Size of student enrollment.
3. Type of legal school district.
4. Tax rates.
5. Assessed valuation per resident pupil.
6. School expenditure per pupil for instruction.
7. Teachers' salary schedules.

These factors were elaborated and applied as follows.

Geographic-Economic Areas. Ohio can be divided geographically into well-defined areas. This also gave a distribution related to the economic conditions of the districts involved. An attempt was made to achieve a distribution of school districts on the basis of geographical location. The map (Figure 1) indicates the degree to which this was achieved.

A line was drawn from north and south, and another from east to west through Columbus, thus dividing Ohio into four quadrants. Through data available from the Ohio Education Association and the State Board of Education, the economic conditions of the schools were studied in order to achieve an even distribution within each geographically located district.

The northeastern section of Ohio includes the Mahoning Valley, which is characterized by the steel industry, while the southwestern section is characterized by soap, paper, meat packing, and the machine tool industries. The northeastern section is chiefly heavy industry, in contrast to industry of a lighter nature of the southwestern section. These two quadrants, however, contrast sharply with the northwestern and southeastern sections, which are primarily rural.

Further consideration was given to the population background within these geographic areas. The northeastern section of Ohio has a large proportion of second and third generation immigrants of German, Italian, Hungarian, and Czechoslovakian heritage. The southwestern section has a substantial second and third generation population which is largely of German descent. These factors should be reflected in the characteristics of schools invited to participate in the study. Surrounding each of the industrialized areas indicated above is a huge metropolitan community which is supported through the economic contribution of the characteristic industry.

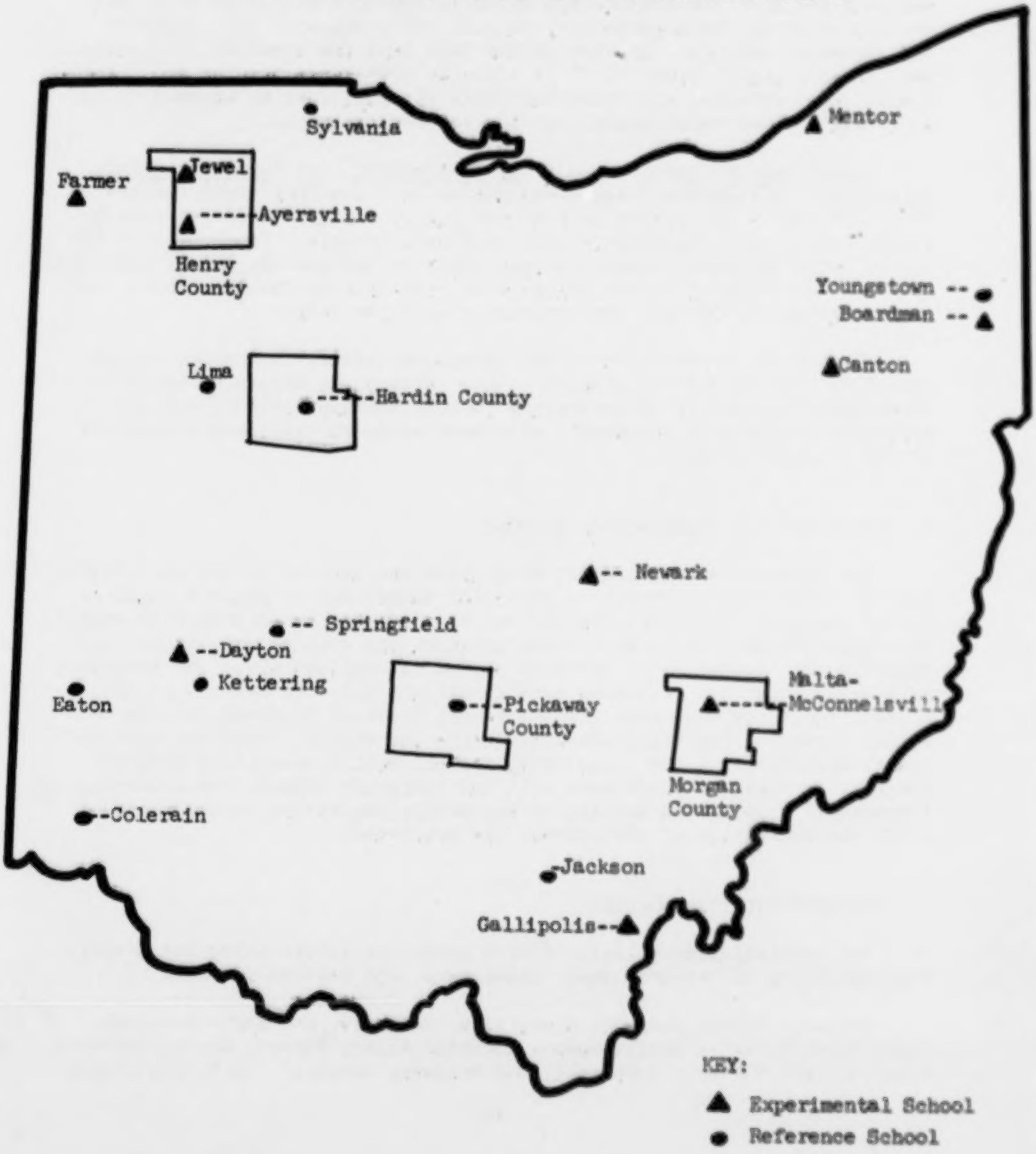
The northwestern quadrant of Ohio is largely rural, with much productive agriculture. This quadrant has a high degree of economic prosperity compared with the southeastern quadrant, which is quite hilly and with limited agricultural resources. Only a moderate amount of industry is found in either of these quadrants. The kind of school district that is found in one quadrant of Ohio, therefore, may stand in contrast with that found in another quadrant. A few school districts declined the invitation to participate, however, and, as a result the final selection did not match completely the original plan.

Size of student enrollment. The second factor in the selection of schools was the total student enrollment. Those schools below a specific enrollment figure were not considered for research purposes. An arbitrary index was devised on the basis of the ratio of science and mathematics teachers to the total enrollment. When it was found there would be less than approximately five teachers who would be involved with the program, the school was not invited. However, because of other factors that eventually entered the selection process, two districts with only three teachers each were involved in the program.

Type of legal school district. Legally there are three kinds school districts in Ohio. These are city districts, exempted village districts, and county districts. All types were involved in the research project. The county districts are composed of local schools. Each local school has its own board of education. An effort was made to distribute the schools

Figure 1. State of Ohio

Distribution of Experimental and Reference Schools


Sylvania
Mentor
Jewel
Farmer
Ayersville
Henry County
Youngstown --
Boardman --
Canton
Lima
Hardin County
Newark
Springfield
Dayton
Kettering
Eaton
Pickaway County
Malta-McConnelsvill
Morgan County
Colerain
Jackson
Gallipolis
KEY:
▲ Experimental School
● Reference School

equally throughout these categories. Some schools were from city districts, some were from exempted village districts, and some from local districts. In three cases the research involved an entire county system.

Tax rates, and assessed valuation per resident pupil. The school tax rates (for operation and total) and the percentage of the all-purpose tax rate going to the schools are shown in Appendix F. It is noted that the tax rates in the experimental schools are comparable with those in the reference schools. In view of the fact that the assessed evaluation per resident pupil (Appendix F) is likewise comparable for the two classifications of schools, the financial basis per pupil can be assumed to be equivalent in the experimental and the reference schools.

School expenditure per pupil for instruction, and teachers' salary schedules. In Appendix F are given the average cost per pupil for instruction, the total operating cost per pupil, and the teachers' salary schedules for both experimental and reference schools. Comparison of the expenditures in these categories (per pupil costs) and the salary schedules, which are an index of school policy with reference to faculty, shows that the two groups of schools are comparable on these bases.

Through the application of the foregoing factors in the process of selecting schools for the research study, reasonable assurance was provided that the schools participating in both the experimental and the reference groups were comparable with each other and were representative of the schools in Ohio.

B. REFERENCE AND EXPERIMENTAL SCHOOLS

The research design did not anticipate the need of so-called "control" schools. However, to provide a basis for comparison of schools involved in the research with other schools not so involved, two groups were chosen. The experimental schools were those in which the science and mathematics teachers were taught for a two-week period as outlined above and described in detail below; the reference schools did not have the benefit of this instruction. For each experimental school district selected, a reference school district of similar characteristics was chosen. Only the experimental districts had the opportunity for the mobile laboratory program. However, arrangements were made with the reference schools for a one-day informative meeting and display of the mobile laboratory, which occurred after the evaluation of the schools was completed.

C. THE PARTICIPATING SCHOOLS

The participating schools of each group are listed below and identified according to research type, legal type, and section of Ohio.

Defiance County included Ayersville, Fairview, and North Richland-Adams Schools, while Hardin County included Alger, Forest, Hardin Northern, McGuffey, Mt. Victory, Roundhead, and Ridgeway schools. In Morgan County only the Malta-McConnelsville school was included, while Pickaway County included Salt Creek, Ashville, Scioto, Walnut, Atlanta, Darby, Jackson, Monroe, and Williamsport.

Table I

Identification of Participating Schools According to Research Type, Legal Type, and Section of Ohio

District	Research Type*	Legal Type	Section of Ohio
Boardman	Experimental	County	Northeast
Canton	Experimental	City	Northeast
Colerain	Reference	County	Southwest
Dayton	Experimental	City	Southwest
Defiance Co.	Experimental	County	Northwest
Eaton	Reference	City	Southwest
Gallipolis	Experimental	City	Southeast
Hardin Co.	Reference	County	Northwest
Jackson	Reference	City	Southeast
Kettering	Reference	Exempted Village	Southwest
Lima	Reference	City	Northwest
Mentor	Experimental	Exempted Village	Northeast
Morgan Co.	Experimental	County	Southeast
Newark	Experimental	City	Southeast
Pickaway Co.	Reference	County	Southwest
Springfield	Reference	City	Southwest
Sylvania	Reference	Exempted Village	Northwest
Youngstown	Reference	City	Northeast

*Participating schools are considered to include both classifications -- experimental and reference.

Individual city schools included the Senior High and the ninth grades in Central and South Junior High Schools in Lima. Belmont High School in Dayton participated in the study as did Woodrow Wilson High School in Youngstown. Lincoln High School in Canton was also included in the study.

VII. PLANNING WITH THE SCHOOLS

The plan of procedure provided for an initial meeting to include a representative from each school participating in the study. Each school was asked to select one science or mathematics teacher to represent the teaching faculty involved and the school administration. The meeting was held on the campus of The Ohio State University. At this meeting the following topics were the central points for discussion:

1. The purpose and rationale of the study.
2. The teaching, study, and research procedures planned.
3. The general nature of the curriculum.
4. The resources to be presented through the mobile laboratory.
5. The anticipated time schedule.
6. The use of a preliminary workshop to plan details with school personnel.
7. The use of a culminating workshop with school personnel to enhance the interpretation of the study and further evaluate the outcomes.

In the course of this initial meeting with representatives of the schools, it was stipulated that the schools should accept the following obligations:

1. The school would supply at least one representative to each of the workshops.
2. The school administration and science and mathematics faculty would endorse the research study and participate whole-heartedly in all phases of it.
3. The school would release all science and mathematics teachers in the junior and senior high school for two or three hours each afternoon for a two-week period to participate in the study.
4. The mobile laboratory would be parked on school property and space in the school building would be made available for the television studies and for the classroom laboratory work.
5. The Board of Education would provide the necessary electric power for the operation of the laboratory.

The Ohio State University accepted the following obligations:

1. A well-planned program of instruction appropriate to the needs of science and mathematics teachers would be presented.
2. The University representatives would cooperate fully with the school administration and faculty in carrying out the instruction and research.
3. There would be no financial responsibility placed upon the schools.
4. The results of the study would be made available to the participating schools.
5. Individual schools in the report would not be identified in presenting the research findings.

VIII. PLAN OF EVALUATION

In view of the fact that the major purpose of the research project was to study means of improving teacher competency in both academic and professional aspects, the measures of evaluation were all so directed. An analysis of the various sources of information to be used in evaluation showed four that held promise of both validity and practicability. They were (1) the teachers themselves, (2) the students in their classes, (3) the supervisors of the teachers, and (4) the school administrators in the participating schools. In addition, other casual sources yielded unanticipated evaluative information which will be introduced into the interpretation at the appropriate points.

Each of the four principal sources could yield more than one kind of information of use in the evaluation. Since teacher competency was the focal point, it was essential to gain such information about the teachers who were being taught. An analysis of the specific measures from each source is herewith presented with a brief description of each. Evaluation forms were developed for most of the specific measures. Code letters were used to designate each such instrument; the code letters assigned are given in the column at the right for reference to the instruments which are presented in Appendix E.

A. EVALUATIVE MEASURES INVOLVING TEACHERS

1. A content examination based on the curriculum in science and mathematics. The examination was based on items prepared by the academic specialists representing the fields of biology, chemistry, physics, — Form DT

Form DT Continued

and mathematics. Five items were concerned with biology, nine with physics, four with mathematics, and three with radioactivity. Multiple-choice items were designed. Identical forms were used for pretesting and posttesting.

Form AT

2. A professional achievement scale based on the stated professional objectives and curriculum. Most of the items used in this form were obtained through an essay questionnaire given to 146 beginning freshmen college students in science. A frequency table of "teacher concepts" thus expressed was constructed to indicate the concepts of good teaching held by these students. From this table a group of statements were selected because of their relevance to the objectives of the mobile laboratory study. A few items were added to the scale because of their greater subtlety in identifying the attributes of good science and mathematics teaching as compared with those obtained from the student essay questionnaire.

   The resulting instrument was composed of 35 items which were subsequently divided into three categories: (1) twelve items were chosen because they were directly applicable to the mobile laboratory and were indicative of the changes attributable to the program of the mobile laboratory; (2) eight items were chosen because they were directly related to the type of behavior of any good science or mathematics teacher in the high school classroom; and (3) fifteen items were selected because they were indicative of good teaching practices of any teacher whether he is from science, mathematics, or any other teaching area.

   Identified as AT-I

   Identified as AT-II

   Identified as AT-III

   The teachers who responded to this instrument were requested to make three separate ratings of themselves: (1) each was requested to rate each statement with respect to the ideal position; (2) each was requested to rate his actual teaching behavior as reflected by the statement; and (3) each was requested to indicate the 10 items from the list of 35 which he considered most important.

Form ET

3. A professional attitude scale designed to determine the teacher's attitude toward his profession and thus a possible relation to his teaching behavior. Such a scale can then be used with the teaching methods scale as rated by the teacher, student, and supervisor. The attitudes of the individual teachers in the experimental schools might also reflect their experience with the mobile laboratory.

Form ET
Continued

The items on this instrument were selected primarily by one of the consultants from his experience in working with teacher rating scales. The self-rating technique was chosen because of expediency and also because of the purpose of the instrument. It was assumed that teachers would appreciate the responsibility of honesty and integrity placed upon them in responding to the instrument.

The instrument was composed of 25 items to which the teachers responded according to the degree of their agreement with each statement. Six of the 25 statements were negative in their approach to professional attitude and the scores for these items inverted in obtaining the over-all score from the instrument. Since each statement was rated on the basis of 1 to 5, a perfect attitude score would have been 125.

Form H

4. A teacher evaluation of the mobile laboratory in relation to its purposes. The instrument was developed from an essay written by the participating teachers during the last hour of class work with the mobile laboratory. To stimulate their thinking, several questions and suggestions were offered. First, the teachers were asked to express their reactions toward the amount of time the project demanded of them. This was in reference to three hours per day, and ten days of time. They were reminded that such an in-service program after school hours may have been extremely tiring after a long teaching day, and that it probably had been difficult for them to do their best in such a program. Second, the teachers expressed their thoughts on the over-all effectiveness of the mobile laboratory program. They were asked to consider the methods of presentation and the kind of information brought to them. They were asked to express their thoughts on such an in-service program. Third, an expression was solicited in regard to their attitude concerning television as a teaching medium as well as other reactions they may have had toward it. Fourth, they were asked to express their feelings concerning the curriculum of the mobile laboratory. What was their reaction to this type of program? Did the program contain worthwhile information? Fifth, the teachers were asked to make any recommendations about such an in-service field approach.

The essays thus prepared were analyzed in the following months for their definitive statements of evaluative nature. These were selected to become the basis for an evaluative instrument to be administered from four to six months after the instructional period provided through the mobile laboratory. Form H Continued

The instrument was composed of 70 items. The evaluative items were divided into five groups. They were time, over-all effectiveness, value of television medium, coverage of information, and other aspects. The response to this instrument employed the forced-choice technique in which each teacher indicated whether he agreed or disagreed with the statement.

5. A synthesis of subjective teacher evaluations developed in group conferences. To obtain an evaluation of the group of science and mathematics teachers in each school, a meeting of these teachers was planned for late September, 1960. Acting as a local committee under the chairmanship of their local representative to the University, the teachers were asked to consider critical aspects of the study, to arrive at a consensus where possible, and to record individual judgments where they differed from group judgments. Form I

The discussion topics for the meetings were as follows:

1. The level of the academic work of the mobile laboratory
2. The development of high school - university relationships
3. Appropriate objectives of similar future research
4. Merits of the approach through instruction of the teachers as compared with an approach through the instruction of students.
5. Degree of accomplishment of the objectives of this research project.

A summary of such discussions, given in a later section of this report, thus presents a relatively unstructured yet not random evaluation.

B. EVALUATIVE MEASURES INVOLVING STUDENTS

Form BST (same as Form AT)

1. The evaluation of teacher effectiveness by the students. In addition to any effect on the breadth and depth of the learning of students attributable to the mobile laboratory, there may be also an increment in the students' perception of attitude, motivation, and effort on the part of their teachers. If such changes in teacher behavior can be detected and their direction determined, the nature and magnitude of those changes can be related to other established outcomes of the period of instruction.

   The instrument used was the same as Form AT, previously described. It was administered prior to and following the period of instruction in both experimental and reference schools. The students were requested to make two distinct ratings of their teachers: (1) each student was requested to respond to each item of this instrument as to whether it was true or false as applied to his teacher; and (2) each was requested to indicate the 10 items from the list of 35 that he thought the teacher emphasized most in classroom teaching. The frequency with which the items occurred in the category, "items related to mobile laboratory visitation" would provide a clue as to the items most important to the student. Similar tabulations for each of the remaining categories, "behavior of any science or mathematics teacher" and "practices of teachers from any area," would provide comparable evidence of that kind. It was assumed that any change in the teaching because of the mobile laboratory would be identified through this forced-choice technique.

2. Academic achievement of the students. The original plan included the possible use of academic tests of student progress given in the experimental and in the reference schools, both as pretests and posttests. The Sequential Tests of Educational Progress (STEP) were chosen with the anticipation that perhaps such an indirect measure of differential effects on the teachers produced by the research could be identified. The tests were given, but because of maladmisistration in the process the results could not be used.

C. EVALUATIVE MEASURES INVOLVING SUPERVISORS

Form CSU
(Same as
Forms AT
and BST)

Supervisors' evaluations of observable changes in teachers. It was assumed that changes attributable to the mobile laboratory in the attitude, motivation, and effort of the teachers might be perceived by the responsible supervisor. The same instrument as that used by the teacher for self-evaluation (AT), and for evaluation by students (BST), was used by the supervisory personnel. Thus, three evaluations on the same scale provide a basis for possible comparison of the same changes in behavior by three groups of persons: the teachers who were the direct subjects of the research, the students who could observe the behavior of their teachers, and the supervisory personnel responsible for the instructional personnel. The supervisors were requested to make two distinct ratings of the teachers: (1) each was requested to rate his teachers on a graduated scale from one to five as to the amount of consideration he thought the teachers gave to such items, and (2) each was requested to indicate the 10 items from the category, "items related to mobile laboratory visitation," which would give evidence of those considered the most important. Similar tabulations for each of the remaining categories, "behavior of any science or mathematics teacher" and "practices of teachers from any area," would provide comparable evidence of that kind. It was assumed that any change in teaching because of the mobile laboratory would be identified through this forced-choice technique.

D. EVALUATIVE MEASURES INVOLVING ADMINISTRATORS

Form F

An instrument based on anticipated outcomes of the superintendents of the experimental schools. Through the development of an instrument based on judgments of the administrators expressed prior to the research operation it was possible to ascertain the degree to which the laboratory lived up to these expectations, and to what degree the laboratory was fulfilling its assumed obligations to their schools. The instrument was used with the superintendent and principals only. However, a similar evaluation was sent to the individual teachers as Form H. These two forms (Form F and Form H) were used with the experimental schools only.

Development of the Instrument. Before the mobile laboratory visited any of the participating experimental schools, each of the superintendents was asked to indicate his expectation of outcomes of such a research study.

The expected outcomes were rewritten in sentence form. These were then compiled into an evaluation instrument as Form F.

Form F Continued

The instrument consisted of 65 items, 40 of which were statements submitted by the administrators as the anticipated outcomes, and 25 of which were other statements relevant to the effectiveness of such an instructional program.

This instrument was completed by each participating principal and superintendent in the experimental schools. The response to each item was expressed on a rating scale of one through five. Those items indicated as "one" were expressed as strongly disagree, while those items indicated as "five" were expressed as strongly agree. The results of each item were averaged according to principal's response, superintendent's response, and group response (principal and superintendent).

IX. PLAN AND SCHEDULE FOR THE PROGRAM PRESENTATION

The theme for the program was the structure of matter. The general outlines for the academic and professional work have been presented on pages 4 to 8. In each school a ten-day period was used for the instruction of the teachers. Three hours were provided each day, with the usual instruction period extending from 2:00 to 5:00 p.m. A brief intermission was provided at approximately the midpoint of the three-hour period.

A. OUTLINE OF THE PROGRAM

First Day. The first meeting with the science and mathematics teachers was exploratory and informative. The basic reasons for the research were explained and the purposes for working with their school were indicated. The questions asked by the teachers reflected their interest and the degree of preorientation given to them by the school representative. At this time the general plan of the program was presented, and an invitation to teach at least one class using the various media was extended to the teachers.

During the orientation time a tour of the mobile laboratory facilities was taken to acquaint the teachers with the extent of the resources. The purpose of this tour was to encourage the teachers to make liberal use of these resources. The second phase of the initial meeting began with a closed-circuit television presentation by the instructor utilizing vectors, and their explanation as recommended by the National Council of Teachers of Mathematics. A two-fold purpose was served by the introduction of vectors at this point. First, there was an attempt to capture the interest of both the mathematics and the science teachers immediately by using a subject common to both the physical sciences and mathematics. Second, the study of vectors was a good example by which to illustrate techniques of teaching using a magnetic board. An added dividend was the preparation it gave for forthcoming materials concerned with the structure of matter.

Following the presentation on vectors, attention was directed to motion. Again, there was a more rigorous approach for teachers familiar with this material as well as a more elementary approach for the individual with a limited subject matter background.

A laboratory period followed with an opportunity for questions, individual work, and visitation to the library of the mobile laboratory. The laboratory time was devoted to work with individual magnetic chalkboards. Teachers who were not familiar with the concepts presented earlier had an opportunity to work them out individually with the magnetic board.

Second Day. The more formal presentations were made through closed-circuit television in two 45-minute periods. Between these the demonstration materials were changed for the subsequent presentation, and the teachers were given a brief rest.

Concepts of the diffraction of light were presented utilizing the ideas developed in the study of vectors and motion. The wave motion of light and the polarization of light were also explained on this basis. Along with the presentation an effort was made to acquaint the teachers with the materials that were available for demonstrating those concepts. Some of the materials demonstrated were constructed expressly for this purpose.

A ripple tank served to illustrate the concept of interference. An interference demonstrator constructed of glass and cardboard was also used. Further demonstration was made with the aid of magnetic cards upon which the figures and data had been previously drawn to facilitate the presentation. A diffraction grating of plastic was used to illustrate the pattern formed from a mercury light source. One of the handmade items used to explain polarized light was a grid made of wooden dowels. Through rotation of this grid it was possible to illustrate the concept of a polarizer or analyzer.

In the second part of the lecture period, atomic structure and certain related concepts were explained. To aid in the explanation of how measurements were made on charged particles, a film on the Millikan oil drop experiment was shown.

The laboratory period which followed continued with problems related to vectors and included experiments with polarized light and the diffraction of light. Teachers were helped to work with the ripple tank and other teaching aids related to the earlier presentation

Third Day. The opening presentation by closed-circuit television developed the concept of resonators and involved the vector concept of wave motion, showing its relationship to the theory of resonance. To illustrate the concept of resonance, an air column was adjusted to resonate with tuning forks. The point of resonance was picked up by the microphone and the visual demonstration carried the idea to the analogous situation in electromagnetic energy. Resonance was indicated as a means of identification of wave characteristics in matter. A dumbbell model of the carbon monoxide molecule was made from Styrofoam balls on a dowel. The sizes of the balls were in proportion to the sizes of the atoms of carbon and oxygen that they represented. The device was rotated about its center of gravity. The resonant motion of this model as related to infrared energy was explained to be a means of measuring the molecule itself. With these explanations the physics kinescope on infrared radiation was presented, thus elaborating the concepts already introduced.

In order to develop a concept of the relationship between molecular structure and geometric formations of crystals, a visual demonstration of crystal structure was made with D-Stix. Fisher-Hirschfelder-Taylor models were used at this point to give the viewer an idea of the relative sizes of the atoms that enter into a chemical reaction. One objective was to develop an understanding, beyond that ordinarily given in general college chemistry, of the factors that cause chemical reactions to go forward.

The second part of the presentation developed the relationship between chemical reactions and the structure of atoms. Since the measurement of chemical bonds had been explained in terms of resonance, the presentation led into the chemistry kinescope which explained one aspect of the theory of chemical reactions.

In the laboratory period Styrofoam balls and pipe cleaners were used by the teachers to make molecular models and to illustrate possible types of resonance which occur within molecules. Also included in this laboratory work were the use of the diffraction grating and the measurement of the wavelength of light.

Fourth Day. Photosynthesis was introduced utilizing explanations based on resonance with certain frequencies of electromagnetic radiation. The chemical structure of chlorophyll was explained, and the chemical reactions that occurred because of its chemical structure were introduced. The formal presentation was illustrated by slides. Important points were quickly illustrated by cards, held magnetically to a metal display panel, on which chemical formulas and similar material had been prewritten.

Two films were shown at this time in a continuing plan to bring information on current university research to the school. One film showed the research on the male frog test for pregnancy and the other was on the life cycle of the frog.

Chromatography was the theme of the laboratory period following, with the teachers participating in the physical separation of the leaf pigments into several compounds. Since the explanations on chlorophyll and chromatography had preceded this laboratory period, the laboratory work was directly related to the lecture-demonstration. Along with the separation of chlorophyll, the activation of the chlorophyll by ultraviolet light was explained. This activation was apparent from the observed fluorescence and led to an interesting discussion of a related subject. The teachers were reminded at this point of the mathematical vector factors of the wavelengths of energy that excited the chlorophyll. The presentation integrated the content presented thus far in the demonstrations and laboratory sessions.

Fifth Day. The concept of isotopes was presented using Styrofoam balls to which iron impregnated magnetized tape was glued. These were used to construct two-dimensional models of various isotopes on the magnetic board. Previously prepared slides showing the disintegration of radioactive nucleii, the concept of half life, and a half-life curve were projected as a part of the presentation. By electronic superposition it was possible for the instructor to point at will to the parts of the projected image.

Tracer methods making use of radioisotopes were described, such as those used to detect the chlorophyll reactions presented on the preceding day. A demonstration through which biology teachers could use these techniques for describing the CO_2 fixation process was explained. Other experiments proposed but not carried out included the use of chloroplasts and a strong light. Such demonstrations as these were not feasible within the mobile laboratory because of freezing weather.

The historical aspects of radioactivity were discussed briefly as an introduction to that field. The types of radiation resulting from nuclear disintegration were discussed using the magnetic chalkboard and magnetic Styrofoam balls appropriately marked as plus (proton), minus (electron), or N (neutron). The half-life concept of the isotopes was also illustrated with the magnetic Styrofoam balls.

Fundamentals of the operation of Geiger counters were explained with the aid of charts, drawings, and slides. Techniques of safe handling of radioactive isotopes were presented. The use of isotopes in the classroom was encouraged as a tool in demonstration work just as one would use acids and bases for laboratory experiments.

The laboratory period permitted the teachers to familiarize themselves with counting devices. The teachers were assisted in studying the equipment and in attempting for themselves some of the operations suggested from the more formal presentation.

Sixth Day. A major objective in the first session was to develop a realization of the need for a statistical approach to radiation counting. A practical demonstration using Styrofoam balls was undertaken to indicate a way that statistics might be taught in the high school classroom. This presentation was made with a number of prepared magnetic devices and the use of hypothetical problems, the more complicated based on radiation counting.

To acquaint the teachers with a practical method of handling such problems in the classroom, demonstrations of problems in probability were given with the aid of Styrofoam balls of various colors. It was suggested that the materials were cheap enough to be obtained in quantity for all members of a mathematics class so that the principles of probability could be developed by the pupil. Spinning pointers which would come to rest over numbered sectors on a disk gave variation to this approach. Both of these techniques were suggested in the Twenty-fourth Yearbook of the National Council of Teachers of Mathematics.[1] Finally, a practical problem in radioactive counting utilized the concepts presented in probability and statistical analysis.

By this time in the program the teachers realized their need for more direct experience with laboratory apparatus. Since the laboratory equipment was limited in quantity, necessary rotation schedules for its use were established.

Seventh Day. The presentation consisted of explanations of proportional counting, flow counting, scintillation counting, and radioactivity in relation to health. A technical explanation as well as a theoretical explanation was given of the proportional counting region. The explanation of the structure of the atom, which had been given in previous presentations, was used to show how the energy of the isotope could be measured with a proportional counter. This was also demonstrated visually through the use of an oscilloscope. Graphs and charts with magnetic tape were used as well as a small flow counter to explain more fully the proportional counting theory. The presentation included the level of energy that can be measured by the proportional counter, and the techniques that are employed to use the gas within the counter itself as an amplifier.

The flow counter operation was explained briefly. The similarities and differences of the two counters were then discussed. The suggestion was made to the teachers that in the purchase of expensive counting equipment, the types to which accessory items can be added are preferable because of increased versatility.

Scintillation counting was explained on the basis of the photoelectric effect. The teachers were informed that the scaling device in the mobile laboratory was adaptable not only to the Geiger tube, but also to the flow counter and to the scintillation counter. A single project for classroom experimentation with a spinthariscope was described along with the necessary directions for the construction of a spinthariscope.

The types of crystals commonly used for scintillation counters were explained, and sources of photomultiplier tubes that could be used for this purpose were suggested. The teachers were encouraged to construct such devices in order to help students who would be interested in this kind of work.

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[1] The Growth of Mathematical Ideas Grades K-12. Twenty-fourth Yearbook, National Council of Teachers of Mathematics. Washington, D. C.: National Council of Teachers of Mathematics, 1959. David A. Page, "Probability," pp 229-271.

Examples of practical classroom demonstration using radioisotopes were presented. The results of previous experiments of this kind were displayed. Radioautographs made by fish bones and the dial of an alarm clock were among the displays.

Since the health hazard associated with radioactivity is a frequent question raised by students, this topic was given careful consideration. To provide a common understanding, energy from radioactivity was compared to a reagent such as nitric acid. The effects of this energy on the body were discussed and the results of extended exposure were explained. The biological changes produced within the cells and the resulting physiological effects were discussed. Prepared slides and magnetic cards were used in the discussion. The teachers were reminded that every science laboratory has its hazards, and that the hazard from properly used radioactive materials is no greater than that in using concentrated acids or alkalis. The need for careful handling of all such materials was emphasized.

Current research with animals to learn more about the hazards of and medical treatment for radiation exposure was considered. There was also a brief description of the chemistry involved in the disturbed body processes. A comparison was made between problems resulting from the radiation exposure of human beings and such problems among lower animals.

Eighth Day. Various aspects of professional education were presented in the two-week period, and especially during the eighth day. In keeping with the experimental spirit of the mobile laboratory, teachers were helped to experiment with techniques of teaching other than those customarily used. Along with this approach, self-evaluation of the outcomes of such new experiences was encouraged.

The participants were encouraged to sense and define problems of teaching. It was suggested that the teacher utilize individual student interest in identifying problems in the classroom and the laboratory. Techniques designed to achieve these goals were suggested. Practical examples of the methods used in other classrooms were given, accompanied by slides to illustrate them.

This presentation included a consideration of the participation of students in science fairs. Deficiencies of the science fair were identified, as were the assets. The emphasis on winning the blue ribbon rather than on learning, and participation in the science fair program as an outlet to a teacher's frustration were cited as weaknesses. On the positive side of the science fair program such things as the encouragement of self-expression, recognition of achievement, and the discovery of creative ability were recognized. Along with these aspects of the program, the problems of competent judging were discussed.

Practical suggestions were made with respect to science facilities and demonstration techniques. The clear visibility of demonstrations to all members of a class and the problem of storage space for demonstration equipment of adequate size are important aspects of both science and mathematics teaching. The presentation of conflicting evidence was cited as a means of involving the class as a whole in the learning process. This involvement helps to develop student interest.

The consideration of professional problems then turned to the more effective use of the science laboratory in the secondary school. The presentation was made by means of a kinescope. The functions of the laboratory were first discussed by Professor Schlessinger, of the Department of Education. Mr. Slesnick, of the University School, then presented a phase of the work in that school through a visit to a science laboratory in action and discussion of the work with several of the pupils. The presentation of the kinescope was followed by teacher discussion of the appropriate functions of the laboratory in science and mathematics teaching.

Sixth Day. Professor Harold P. Fawcett was in charge of a program giving major emphasis to mathematics and mathematics teaching. The first phase of his contribution was a presentation of the new (or modern) mathematics in relation to the high school curriculum. The second phase included a discussion of the teaching of mathematics.

The historical background of mathematical curricular development was summarized to show how static the teaching of mathematics has become. The need for teachers to give the subject new vitality, reflecting the continuing growth of selected mathematical ideas, was emphasized. The similarities and differences of several proposed programs of secondary school mathematics were presented.

The need to develop concepts, to nourish their growth, and to broaden their applications was stressed as important to the college-bound as well as the terminal student. The fact that teachers of mathematics frequently do not teach concepts but rather teach only operations was deplored. Concrete examples of this and of the outcomes of such teaching procedures were given. The basic difficulty was described as "mathematics teachers who have tended to feast the memory and starve the reason." The Twenty-fourth Yearbook of the National Council of Teachers of Mathematics, which recognizes the mathematics curriculum as the growth of a small number of selected major concepts, was discussed and illustrated.

The problems of symbolism in the languages of mathematics were presented as a source of major difficulty. Teachers were encouraged to make sure the mathematical symbols stand for ideas in the thoughts of their students. Associated with this emphasis, the concepts of number and operation, measurement and approximation, sets, relation and function, probability and statics, as well as the nature of proof were considered as threads of continuity tending to unify a mathematics program. Each of these concepts was treated separately in an effort to illustrate classroom procedures which reflect this kind of teaching.

During the second phase of the three-hour period the concepts mentioned above were included in a general discussion of methods of teaching. The discovery technique in mathematics teaching was emphasized, and a practical demonstration using the circle as the basis for discussion and generalization was presented. Practical examples of the use of this teaching technique were given along with the results of such teaching procedures. This presentation was concluded by a motion picture* on the discovery technique in teaching the concept of pi.

Tenth Day. The major emphasis in the concluding day was the relationship of facilities to the quality of science and mathematics teaching. Because of the great range and depth of experiences to be provided to students of varying interests, backgrounds, and ability, and because of the many facets of the two subject fields, the facilities for effective teaching must be chosen wisely. The purpose of the culminating presentation was to integrate the professional theme of the mobile laboratory with certain practical aspects of teaching.

Basic principles underlying science teaching facilities as presented and developed in the volume, School Facilities for Science Instruction[2], were used as points of departure in a consideration of how to plan new facilities and to improve those already in existence. Such general requirements of science and mathematics teaching as the following were given primary consideration: lighting, heating, and ventilation; area requirements in relation to class size and the nature of learning activities; and the relation of room decoration to the psychological aspects of learning.

Selected topics of more specific nature were chosen for the concluding discussion. Among these were the choice of teaching apparatus, the maintenance of equipment, the developmetn of a science museum, the use of a project room, and the preparation of teaching aids for science and mathematics.

The culmination of this presentation was the preparation, by each teacher, of a sketch on graph paper showing an idealized plan for science and mathematics teaching facilities. Each teacher's plan was compared with one he had prepared on the eighth day, before the study of facilities was made. The activity thus served for both instructional and evaluative purposes.

The closing discussion for the ten-day program was both practical and idealistic in nature. Adequate facilities should provide realistic avenues to lead us toward the new horizons for learning. The analysis of the need for such facilities for science and mathematics teaching provided the unifying summary.

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*"The Meaning of Pi," Coronet Instructional Films.

[2] John S. Richardson, ed., School Facilities for Science Instruction. Washington, D.C.: National Science Teachers Association, 1954.

B. SCHEDULE FOR THE ACTIVITIES OF ONE DAY

It is unlikely that any one day in the total period of field use of the mobile laboratory could be identified as being entirely typical, but it is useful to select one day for a somewhat more detailed view of representative activities. Such an example is provided below. It will be noted, however, that the two parts of the day's program were separated into morning and afternoon sessions in this example. All persons except Mr. Diehl were members of the local school staff.

Mr. Stevens - - Preparation for TV biology teaching	8:00 a.m. to 8:45 a.m.
Mr. Diehl - - Regular TV presentation from mobile laboratory curriculum	8:45 a.m. to 10:10 a.m.
Mr. Bamburger - - Preparation for TV science teaching	10:15 a.m. to 11:00 a.m.
Mr. Stevens - - Teaching biology class via TV	11:03 a.m. to 11:45 a.m.
Mr. Brothers - - Teaching chemistry class via TV	11:45 a.m. to 12:30 p.m.
Miss Hopkins - - Preparation for TV mathematics teaching	1:15 p.m. to 2:00 p.m.
Mr. Heestand - - Preparation for TV teaching (during laboratory program)	3:30 p.m. to 4:15 p.m.
Mr. Diehl - - Laboratory program for teachers	3:30 p.m. to 5:00 p.m.

It was necessary to prepare the equipment for use at least thirty minutes before actual scheduled use. This required that the personnel be at the school before 7:30 a.m. Usually a period of 30 to 45 minutes was required to put things away after the active program of the day. Thus the staff did not leave the building until approximately 5:45 p.m.

X. VISITS TO REFERENCE SCHOOLS

Following the completion of the instructional period in all of the experimental schools, the mobile laboratory was taken for a brief visit (one or two days) to each of the reference schools. All evaluation measures involving the reference schools had been completed prior to this step, thus safeguarding their responses from any bias that might follow.

The visit of the mobile laboratory to the reference schools served to maintain good professional and public relations with those schools. It can be presumed that it provided at least a modest stimulus to the teaching of mathematics and science in those schools.

At each school the mobile laboratory was put on display, its operations demonstrated, and its resources explained. A short sample program was presented. The teachers were given opportunities to discuss the content and procedures of the program, and the research operation itself.

The visits to the reference schools had the further value of testing the utility of a mobile laboratory for a very brief visitation period in reference to possible operation of this type in the future.

XI. EVIDENCE OBTAINED FOR EVALUATION

A. ANALYSIS OF RESULTS FROM EVALUATION INSTRUMENTS

Evaluation form: DT, AT, BST, CSU, and ET (see Appendix E) were subjected to statistical analysis to determine the significance of the results that were obtained. Through recommendation of the consultant involved with this phase of the program, the Wilcoxon matched-pairs signed-ranks test[5] was chosen, since it would indicate the level of significance of greater pairs and would indicate significance in rank differences in order of absolute size. To begin to test these instruments statistically it was necessary to test a null hypothesis that the two samples indicated no significant measurable change between the experimental and reference groups. If this assumption is proved incorrect, then it is possible to assume that there was a significant difference in the response on the evaluation instruments. To establish a statistical basis for the study, a significance level of 0.01 or less was assumed to be "very significant," while the level between 0.01 and 0.05 was assumed to be "significant," ant that from 0.05 to 0.10 was assumed to indicate a "trend."

1. Achievement in Content Fields

Instrument DT was a content examination based on the curriculum in science and mathematics. The teachers' responses indicate a significance level of 0.0174. This level indicates that the data derived from this instrument are significant, and that a marked positive change did occur in the academic preparation of the teachers involved in the experimental phase of the study. The degree to which the change did occur is also interpreted as significant as shown by the Wilcoxon test.

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[5] Siegel, Sidney. _Nonparametric Statistics for the Behavioral Sciences_. New York: McGraw-Hill Book Company, 1956. pp. 75-83.

2. Achievement in the Professional Field

Interpretation of Data from Forms AT, BST, and CSU

Instruments AT, BST, and CSU were subdivided into three categories. (1) Roman numeral I indicates the selection of items from the instrument which are most directly related to the primary objectives of the study (p. 1). The items so related, numbered as they appear in the evaluation form, are:

1. The teacher uses a variety of methods in his teaching.

5. Demonstrations are planned to stimulate student thinking.

6. An adequate background in the subject is evident in the teacher's teaching.

10. Original problems, experiments, models, and apparatus are developed by the teacher.

12. The theory of the subject is closely related to everyday living.

15. The teacher encourages frequent use of books, references, and other source materials.

18. Proper instruction is given in the use of source materials.

19. The teacher uses good scientific reasoning throughout the classroom experience.

22. Course materials are adapted to individual interest and ability.

30. Students are permitted to familiarize themselves with laboratory equipment by working with it both individually and in groups.

33. Students are encouraged to solve problems by more than one method.

35. Estimation of answers is encouraged before problem solving is begun.

(2) Roman numeral II indicates the selection of items from the instrument which are most directly related to science and mathematics teaching in general. However, these items are not necessarily related to the primary objectives of the study. The items in this category, numbered as they appear in the evaluation form, are:

2. Students are encouraged to think through problems in a scientific manner.

3. Students are encouraged to follow approved steps in their science and mathematics problem solving.

9. Stimulating field-trip experiences are carried out.

14. Student preparation is adequate for advanced work.

16. Emphasis is placed on careful and detailed work.

20. Students are trained in good scientific observation, thinking, and reporting.

26. The classroom program takes advantage of world-wide resources.

31. Students are encouraged to theorize from factual data.

(3) Roman nuberal III indicates the selection of items from the instrument which are *most directly related to teaching in general and not uniquely related to science and mathematics teaching*. Furthermore, they are not necessarily related to the primary objectives of the study. The items in this category, numbered as they appear in the evaluation form, are:

4. Assignments are explained clearly.

7. Good discipline is maintained.

8. The teacher shows a personal interest in his students.

11. Chalkboard illustrations made by the teacher are easy to follow and are well labeled.

13. The teacher seems enthusiastic about his subject.

17. The program is enriched through outside speakers.

21. Student problems in understanding subject matter receive due consideration.

23. Grading (or marking) is just.

24. The program is enriched through the use of movies.

25. The class periods are well planned.

27. Individual help is given when needed.

28. The teacher is an effective speaker.

29. Effective use is made of bulletin board materials.

32. Thought beyond the material assigned is encouraged, but is kept relevant to the discussion.

34. Students are encouraged to think beyond the basic mechanics of a problem.

The table below presents the data given in Appendix F with reference to the level of significance of the responses of teachers, students, and supervisors in each of the three categories.

Teachers		Students		Supervisors	
AT-I	0.1232	BST-I	0.2938	CSU-I	0.4472
AT-II	0.1236	BST-II	0.2076	CSU-II	0.1232
AT-III	0.8966	BST-III	0.0688	CSU-III	0.2840

3. Achievement of the Primary Objectives of the Study (Category I)

Category AT-I (teachers' responses related to the primary objectives) indicated a significance level of 0.1232, while Category BST-I (students' responses in the same category) indicated a significance level of 0.2938. Category CSU-I (supervisors' responses in the same category) indicated a level of significance of 0.4472. With no group is the level of significance low enough to satisfy the criterion established above even for a "trend." The teachers' responses come close to indicating a trend toward meeting the primary research objectives, but the student and supervisor responses show less indication that the results are reliable. It is interesting to note that the results seem to be less significant the more remote the the respondents were from the actual operation.

4. Achievement in the Improvement of Science and Mathematics Teaching in General (Category II)

Category AT-II (teachers' responses toward the improvement of science and mathematics teaching) indicated a significance level of 0.1236, while Category BST-II (students' responses in the same category) indicated a level of significance of 0.2076. Category CSU-II (supervisors' responses in the same category) indicated a level of significance of 0.1232. None of these categories indicated a numerical level of significance low enough to provide firm evidence that the mobile laboratory made a significant change in the responses on this insturment. However, in the responses of teachers and supervisors the significance level approached that of a "trend."

5. Achievement in the Improvement of Teaching in General (Category III)

Category AT-III (teachers' responses to items related to teaching in general) indicated a significance level of 0.8966. Category BST-III (students' responses in the same category) indicated a level of significance of 0.0688. Instrument CSU-III (supervisors' responses in the same category) indicated a level of significance of 0.2840. The students' responses indicate a "trend" and border on "significant." The responses of the supervisors and teachers show no significance.

It is useful to consider the responses of each group -- teachers, students, and supervisors -- to each of the three categories, I, II, and III.

Teachers. The levels of significance in Category I (0.1232) and Category II (0.1236) approach a "trend." This may suggest a positive reaction to the primary purposes of the study and to the improvement of science and mathematics teaching. However, the level of significance in Category III (0.8966) indicates no relationship to the improvement of teaching in general.

Students. Unlike the teachers, the students did not sense a relationship in Categories I and II, but showed a "trend" bordering on "significant" in Category III (0.0688) with respect to the improvement of teaching in general.

Supervisors. No relationship was established in the supervisors' perceptions of the purposes of the study nor in the improvement of teaching in general. However, the level of significance of responses from this group of personnel in the perception of improvement in the teaching of science and mathematics (Category II) was 0.1232, thus approaching a "trend."

6. Achievement in the Development of Professional Attitudes

Instrument ET was designed to determine the teacher's attitude toward his profession. The teachers' responses toward teaching attitudes indicate a numerical level of significance of 0.4010. This level is to high to be of value in this study.

7. Evaluation of the Mobile Laboratory by the Teachers in the Experimental Schools

As described on pages 17-18, Form H, Evaluation of the Mobile Laboratory by Teachers, was developed from essays previously prepared by the teachers. This instrument was administered to the teachers in October, 1960, a period of from 4 to 6 months having elapsed since their instructional experience with the mobile laboratory. The instrument is presented in Appendix E.

The evaluations of the teachers were solicited in five principal categories. They were:

(a) the time required

(b) over-all effectiveness of the program

(c) usefulness of the television medium

(d) value of the curriculum

(e) other aspects of the program.

The instrument permitted the teacher to agree or to disagree with each of its seventy statements, or to abstain from a commitment. The percentage of response is given in Appendix F. For only five items were the abstentions greater than 10%; one of those five was directed to the apparently small minority of science teachers who were actively engaged in work with science clubs, and thus the total response on it was quite limited.

(a) The time required for the mobile laboratory presentation

The judgment of the teachers seemed to be that ten days of time was near the optimum. Seventy-five per cent disagreed with the statement that ten days was too much time, and fifty-eight per cent disagreed that ten days was not enough time.

With respect to the amount of time per day, there was apparently agreement that three hours per day was near the optimum, with perhaps some feeling that it was a bit too long. Seventy-five per cent disagreed with the statement that three hours per day was not enough time, while fifty-nine percent disagreed that three hours was too much time. However, only fifty-six per cent thought that three hours per day was optimum, while thirty-four per cent disagreed with this judgment.

(b) The over-all effectiveness of the mobile laboratory

There was a definite majority of judgments in practically all respects attesting to the effectiveness of the mobile laboratory. For example, it created an awareness of the possibilities of educational research (84% agreed, 14% disagreed). With respect to the classroom, it encouraged the teacher to try his own ideas (64% agreed, 34% disagreed), it stimulated better classroom teaching (72% agreed, 27% disagreed), and created enthusiasm with reference to the teacher's specific interest (62% agreed, 34% disagreed). The mobile laboratory was considered to be a good idea (64% agreed, 30% disagreed), and an aid in adjustment to the changing times (69% agreed, 22% disagreed).

Somewhat positive but less favorable judgments were offered with respect to the teacher's ability to use the information presented through the mobile laboratory (55% were positive, 45% negative). The projection of the University into the school through the mobile laboratory was only moderately accomplished (47% agreed, 50% disagreed).

In the teachers' judgments, only moderate success was evident in the usefulness of the apparatus in the mobile laboratory to the teacher's work (50% agreed, 47% disagreed), but the apparatus was considered appropriate to the needs of the high school science laboratory (59% agreed, 33% disagreed). The teaching aids presented made the program of the mobile laboratory more effective (84% positive, 9% negative), and the films, slides, and charts were judiciously used (72% agreed, 25% disagreed). However, portable science and mathematics museums to be moved into the school during the mobile laboratory visitation would have been valuable (agreed 69%, disagreed 28%).

The library in the mobile laboratory was apparently not very successful in stimulating teachers to request books for the school library (22% had requested books, 77% had made no request). Somewhat greater stimulus was provided with respect to laboratory equipment and teaching aids (34% had made such requests, 64% had not).

The University attempted to create a favorable learning situation for the teachers by requiring that the school make its time available for at least two hours from the normal school day as a part of the three-hour study period. In spite of this, the teachers felt that the tiring teaching day limited their best efforts in the program (73% agreed, 23% disagreed) and that regular teaching duties interfered with their work (73% agreed, 23% disagreed).

(c) Usefulness of the television medium

The use of closed-circuit television for certain of the more formal presentations drew various judgments. The use of television developed an understanding in the teachers of the problems of producing a good class presentation by this means (agreed 83%, disagreed 12%). Many teachers felt that it was easy to change the concept of television as entertainment to the concept of its use as an educational tool (agreed 64%, disagreed 36%). However, a substantial judgment was offered that it was difficult to overcome the impersonal effect of television presentations (56% difficult, 34% easy).

The oportunity for the teachers to teach by closed-circuit television was not considered by a significant percentage to be an asset (27% positive, 56% negative). The teachers would not, in general, favor being required to teach their classes by television (33% for, 67% against). A large preponderance found it more difficult to concentrate on the television screen than on other media of communication used in teaching (86% more difficult, 8% less difficult).

(d) Value of the curriculum

The teachers considered that initially the objectives of the program were not clearly defined (36% clearly, 63% not clearly). Through greater experience with the mobile laboratory study the objectives became more clearly defined (57% clearly, 40% not clearly). This lack of clarity with respect to objectives may be related to the teachers' judgments that a preliminary orientation for them should have been held before the arrival of the mobile laboratory (92% agreed, 8% disagreed).

The general plan for the curriculum seems to have been well received. The teachers' judgments revealed that, to a very substantial degree, the program appealed to teachers of mathematics, chemistry, physics, and biology (85% agreed, 13% disagreed). The concepts concerned with the development of science facilities were, in general, considered valuable (65% agreed, 30% disagreed).

The teachers offered a substantial judgment that the scope of the curriculum should have been more limited (78% agreed, 14% disagreed). Judgments were divided as to whether the general pace of the presentations was about right (55% agreed, 44% disagreed).

Confusing replies were offered as to the general level of difficulty of the academic work. That it was too difficult drew an inconclusive response (50% agreed, 47% disagreed); that it was about right, a similarly inconclusive response (45% agreed, 44% disagreed); but that it was too easy drew a less equivocal response (5% agreed, 85% disagreed). The judgments offered with respect to the level of difficulty of the work in the teachers' specific fields of academic interest were similarly inconclusive.

(e) Other aspects of the program

A substantial judgment was offered that, in a comparable future research project, a prepolling of school needs should be made (89% agreed, 8% disagreed). Comparable agreement was evident that, in such a project, more faculty resources from the University should participate in the school program (85% agreed, 13% disagreed).

The basic thread of thought in the more formal presentations (mostly by closed-circuit television) was generally recognized to be acceptable (69% agreed, 27% disagreed). However, there was a substantial judgment that more general discussion time should have been provided (83% agreed, 17% disagreed). Similarly, the time spent in laboratory work was valued; to the proposal that it be increased the judgment was 67% agreed, 30% disagreed. While the research was based on the in-service education of teachers, their judgment that in such future activities their students should be included was significant (86% agreed, 14% disagreed).

Substantial feeling existed that substitutes should have been provided for the teachers while they were involved in the research study. It was their judgment that these substitutes should have been provided by the school (85% agreed, 13% disagreed). To the corresponding statement placing the responsibility for providing substitutes on the administration of the research project, i.e., the University, the judgment was comparable, but not so decisive. The reaction to that proposal was 39% agreed, 58% disagreed.

The conditions of presenting the program were considered, with reservations, not to affect the teachers' attitudes toward the study (67% agreed, 30% disagreed). Likewise, the attitudes of the school principals were, with some exceptions, considered not to influence the teachers' attitudes (56% agreed, 39% disagreed).

The effect of the mobile laboratory research on other teachers in the school was an important consideration in the endeavor. A substantial judgment was offered that it was not a source of irritation among nonparticipating faculty members (77% agreed, 20% disagreed).

B. Evaluation by the Administrators of the Experimental Schools

As described on pages 20-21, the evaluation instrument, Form F, *Mobile Laboratory Effectiveness*, was developed from written statements prepared by the school administrators. These statements of their expectations were expressed prior to the research operation. They were rewritten by the staff of this project in sentence form and combined with other statements relevant to the effectiveness of the instructional program. The judgments of eight superintendents and ten principals of experimental schools were obtained on each of the sixty-five items after the visits of the mobile laboratory were completed.

Each item was rated on a five-point scale, the assigned ratings having the following meanings:

5 Strongly agree

4 Agree

3 Undecided

2 Disagree

1 Strongly disagree.

The ratings given by principals and by superintendents were weighted equally in calculating the values assigned by persons categorized as administrators. The eighteen ratings for each item supplied by these administrators were averaged for each statement. The items were classified according to the eight following categories:

(a) general effect on the staff

(b) teaching methods, techniques, and materials

(c) professional contribution of the mobile laboratory

(d) scientific contribution of the mobile laboratory

(e) instructional and research techniques of the mobile laboratory

(f) effect of the research project on school-community relationships

(g) effect of the research project on school-university relationships

(h) effect of the research project on pupils in the experimental schools.

The average of the eighteen responses for each of the items is presented in Table F-43 of Appendix F. The items are separated according to the above categories and are further subdivided according to their origin as "expectations" or "accomplished results."

(a) General effect on the staff

The administrators agreed that their expectations with respect to the general effect of the research project on the school faculty had been fulfilled, with one exception. They scored between "agree" and "strongly agree" that the over-all teacher performance could be improved (4.55), that the teachers would become aware of the interest of the administration in the instructional program (4.27), and that interest would spread to other members of the staff (4.22); also that the research project would provide an incentive for the teachers to revitalize their teaching (4.44). There was less agreement, however, that the laboratory should be expected to develop an interest in science and mathematics in the teachers (3.88). This value may reflect an uncertainty as to the meaning of the statement.

Some indecision existed as to the accomplished results. The judgment as to the arousal of enthusiasm was divided between "undecided" and "agree" (3.50). Judgment was similarly divided with respect to the fostering of better understanding between the classroom teacher and the professional educator (3.50), but there was agreement that the teachers' general professional attitude was strengthened as a result of the research project (4.00). Less agreement existed as to the development in the teachers of an awareness of the need for better communication (3.88).

(b) Teaching methods, techniques, and materials

General agreement existed among the school administrators that they hoped that the teachers would become familiar with new and promising techniques (4.38) and that the teachers would try such techniques (4.50). Likewise, there was agreement that the mobile laboratory would help to determine how teachers would react to television teaching or the mobile laboratory (4.22) but there was less than agreement that this approach would help to determine the amount of improvement in instruction (3.55). In spite of this reservation, there was general agreement that the project would promote better understanding of the advantages and disadvantages of closed-circuit television (4.27), and would provide an opportunity to observe at first hand the pupil reaction to television teaching (4.05). However, the administrators were undecided as to whether the study would demonstrate the obsolescence of television equipment (3.16).

There was substantial agreement that the mobile laboratory helped the science and mathematics teachers with the latest techniques (4.22) and the latest materials (4.33); specifically, the value of the presentations by demonstration was well agreed upon (4.22), as was the value of using home-made materials (4.00). Less agreement existed as to the quality of information presented on the preparation and use of teaching materials (3.77) and on the guidance in developing classroom skills (3.66). The administrators agreed that the opportunity to borrow resources from the mobile laboratory was one of its worthwhile functions (4.05).

(c) Professional educational contributions of the mobile laboratory

The statements of expectation of the school administrators were in more than average agreement with respect to the professional educational contributions of the mobile laboratory. The average of their scale values indicates that they agreed the study was a good opportunity to help teachers improve their teaching of science (4.22) and mathematics (4.00). Similarly it was agreed that the study was a good opportunity to study modern trends in equipment in science (4.27) and mathematics (4.05). The opportunity to use up-to-date reference material was valued (4.27) as was the availability of professional literature (4.05) and the results of educational research (4.22).

There was slightly less than agreement that the research study was effective in paving the way for future research (3.88). The value of participation of professional educators was agreed on (4.11), but judgments were divided between "Undecided" and Agree" as to whether the project fostered better understanding between the classroom teacher and the professional educator (3.50). The contribution of the library available in the mobile laboratory was scored slightly below agreement (3.88), although there was agreement that the mobile laboratory strengthened the teachers' general professional attitudes (4.02).

(d) Scientific contributions of the mobile laboratory

The school administrators agreed that they expected the mobile laboratory research project to help keep teachers abreast of development in science and mathematics (4.11). They agreed on a hope that it would show interrelationships between science and mathematics (4.05). At the conclusion of the project they agreed that this relationship had been developed (4.00). There was slightly less than agreement, however, that results of current research had been made available in either science (3.83) or mathematics (3.88).

(e) Instructional and research techniques of the mobile laboratory

An optimistic outlook is reflected in the agreement of the school administrators that the study would reveal recent trends in educational research (4.38). A less sanguine expectation that the study would evaluate the current teaching efficiency of the staff was indicated (3.33), or that it would show what subject areas would profit most from such an experiment (3.61). There was considerable indecision (3.16) in their expectation that the study would show the optimum amount of instructional time by television each day and the optimum number of such days each year.

The administrators did not quite agree that the study demonstrated what types of teachers could profit to a greater extent through such a study (3.83). Considerable indecision existed as to whether the mobile laboratory was better than a late after-school or evening period of instruction because it was less tiring (3.22). There was indecision as to whether thirty hours of such experimental instruction was sufficient (3.00), and on the postulate that finding substitutes for the participating teachers was not a major problem (3.00). Reference has been made in (d) above to the near agreement that current research had been made available in either science (3.83) or mathematics (3.88). This judgment may be related to the indecision as to whether it was possible, even with the aid of various teaching devices, for one person to present adequately the material in the various fields of science and mathematics (3.27).

(f) Effect of the research project on school-community relationships

The school administrators were not quite in agreement in a hope that the study would develop in the community an awareness of the need for a strong science and mathematics program (3.77). They were farther from agreement that the project would develop an interest in science and mathematics in persons other than teachers in the community (3.33). There was agreement on the hope that the project would strengthen school-community relationships (4.05).

Agreement on the results accomplished was relatively strong. There was pride in being one of the schools selected (4.38). The community responded favorably to the schools' participation in the research project (4.05), and a definite public relations advantage resulted (4.27).

(g) Effect of the research project on school-university relationships

The school administrators were slightly below agreement that the school should assume part of the professional responsibility for the program (3.88). At the conclusion of the study they were not entirely agreed that better school-university relationships had been fostered (3.66) nor that University facilities had been made appropriately available through this type of field service (3.66).

(b) Effect of the research project on pupils in the experimental schools

It is evident that the school administrators did not view the study as having a very strong direct relationship to pupils in the experimental schools. Slightly less than agreement existed in an expectation that the students would be stimulated directly by the program to greater interest in science and mathematics (3.88). The administrators were less hopeful that the students would be stimulated to enter the teaching profession (3.44).

There was somewhat less than agreement that enthusiasm was aroused in the students by the study (3.70). The administrators were somewhat closer to agreement (3.83) that the time lost by students from their regular classes because of the project was compensated for by the value of the program to the teachers.

C. SYNTHESIS OF INFORMAL EVALUATIONS BY TEACHERS IN THE EXPERIMENTAL SCHOOLS

To obtain the advantage of the perspective of the participating teachers, a second judgment was requested of the teachers in the experimental schools. These teachers were asked to meet as a local committee in each of those schools in late September 1960 to consider certain critical aspects of the work, to arrive at consensus where possible, and to record individual judgments where they differ from majority judgments. The teachers in the experimental schools thus had the advantage of several months to reflect upon their experience and to relate the mobile laboraotry work to their classroom teaching. The local representative prepared a brief statement setting forth the evaluations as prepared by the teachers in his school. He obtained these evaluations in response to the instrument, Form I (Appendix E).

The discussion topics for the meetings of the teachers were as follows:

1. The level of the academic work of the mobile laboratory.
2. The development of school-university relationships.
3. Appropriate objectives of such future research.
4. Merits of the approach through instruction of teachers as compared with an approach through instruction of students.
5. Degree of accomplishment of the objectives of this research project.

An analysis and summary of the judgments of these teachers in the experimental schools, speaking both as individuals and groups, provided a broad spectrum of values under each of the topics, as could be anticipated.

In the summary of the expressed judgments under each topic, the consensus is presented as well as minority divergencies. In a few instances, individual judgments of exceptional nature are included.

1. The level of the academic subject matter of the mobile laboratory.

The level of the work was about right. In general it was stimulating, and should result in continued study and investigation by the participating teachers. The work was comparable to that of subject matter courses open to graduates and advanced undergraduates: suitable for supplementing the teacher's background but too advanced, in general, for actual use in the secondary school.

The level was good for the teacher individually so far as it pertained to his major teaching fields, but became too advanced when topics outside his fields were under discussion. The level could have been set more easily and the project made more effective if the fields included had been fewer. The relative emphasis on science as compared with mathematics was too great. One teacher suggested that future efforts should not attempt to include both science and mathematics.

2. The development of school-university relationships.

The net effect of the research in this respect was almost uniformly positive, in the judgments of the teachers. Appreciation was expressed for the efforts to bring, through these media, the campus to the school. The presentation of a few of the research studies was valued; there was a wish that more of this activity had been included. The possible contribution of colleges and universities to high school programs was placed in a new and favorable light. The invitation to participate in a university research project had a good effect on the schools. The most desirable situation, educationally, is for the school to have such relationships with many colleges and universities, not with just one institution.

More planning and orientation would have helped. In particular, the University (The Mobile Laboratory Study) should have provided substitute teachers. In one school where the decision to participate in the study was made without complete administrative communication, the school-university relationships were not improved, and probably were weakened. Resentment was apparent in some of the teachers.

3. Appropriate objectives of such future research.

Any similar research in the future should be centered on comparable instructional objectives: to further correlate science and mathematics, to keep teachers up-to-date in these fields, to acquaint teachers with new equipment, methods and materials, and techniques and programs suitable for classroom use. Teachers need an opportunity to see and use a wider range of materials than would normally be feasible. One individual suggested that more down-to-earth instruction is needed.

The objectives should not be limited to a narrow group; rather, the research should compare the value of a mobile laboratory in a larger school system having more elaborate resources with its value to a smaller, less well equipped school district. One teacher suggested that by arranging correct timing among the participating schools, the mobile laboratory would strengthen the science-mathematics curriculum of a group of schools at little cost to each.

The objective should be narrowed for teachers within limited fields. The objectives should be simpler and more easily measurable; they should be more clearly explained.

4. Merits of the approach through instruction of teachers as compared with an approach through instruction of students.

There was general agreement that the primary approach should be through the teacher. Their involvement has a good psychological effect; the opportunity to work with instructional apparatus and materials is good, as is the opportunity to teach science by television.

Students could be involved in the program with some profit to them, at least to a greater degree than that in the present research program. However, the interruption of their classroom work would hardly justify an approach through the students. Too much of what is appropriate for the teacher is above what would be valuable to students.

5. Degree of the accomplishment of the objectives of this research project.

The majority of teacher responses indicated belief that, from their viewpoint, the research project had been successful. Evidence already available includes the motivation of teachers to study and to incorporate new ideas into their teaching. Devices and methods of teaching have been altered by several teachers involved in the study, but other teachers are convinced that subject matter content was overstressed at the expense of attention to professional teaching performance.

The degree of accomplishment of the objectives can be determined only by evaluating the increase in academic and professional competence of the participating teachers and by measuring the improvement of the students who shared indirectly in the program. It was suggested by one teacher that further research is necessary for this purpose.

A proper start in the right direction has been made, although the accomplishment has been greater in science than in mathematics. There is opportunity for improvement. The study showed the problems of using television. One teacher, caught in administrative cross-fire, presented the reaction that the study, as designed, was generally unsuccessful and that revision would be needed in any future study.

D. MISCELLANEOUS EVALUATIVE REACTIONS AND SUGGESTIONS

Many evaluative reactions and suggestions were gained during and soon after the completion of the study. In part, such evaluations were direct, having been offered by persons whose association with the project was first-hand; in part these evaluations were indirect, being reflections of the words and actions of others. The principal direct evaluations came from Professor Fawcett and Mr. Diehl. Those of the latter are based on his immediate responsibility for the instructional program each day; Professor Fawcett spent one instructional session (approximately three hours) in each school, with the exception of the first. Another significant evaluation came from a high school principal, as indicated subsequently. These same persons reflected also the reactions and suggestions of teachers, school administrators, and others. A summary of such evaluations, both direct and indirect, follows.

(a) Interest of the teachers.

In general, the observed interest of the teachers was relatively high. In some cases their interest at first was low, but after an initial warm-up period of one or two days, most teachers seemed actively interested. In only one school was there evidence of a clearly significant exception to this generally active interest.

As evidence of this interest, the mobile laboratory instructors reported the manner in which the teachers attacked their own problems and illustrated their ideas with the work of their own pupils. They reported evidence also of growth in respect for and appreciation of the professional judgments of other teachers. The science teachers learned something about recent developments in the mathematics curriculum, as did the mathematics teachers about developments in the sciences; the relationships between the science and the mathematics curricula were strengthened. It was evident that the mathematics teachers became somewhat familiar with the laboratory methods in science, thus deepening their faith in the laboratory teaching of mathematics. In turn, the science teachers learned that, in the mathematics classroom also, the pupils were using the methods of science in the investigation and discovery of mathematical principles.

An outstanding example of the effect of deepening interest on staff morale was reported by one principal as follows:

> This project has actually pulled our entire staff into a more closely knit unit and those teachers that were not involved in this project have taken a second look at some of their preparations and presentations, and have made favorable alterations in their own particular field. This project also meant a great deal of extra work for the teachers involved, but I was most pleased with their willingness to cooperate and make this project a success.*

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*See Appendix F

One teacher reported that the interest of the entire group of science and mathematics teachers was captured.

(b) Cooperation of the staff.

A high level of cooperation was found in nearly all schools, both experimental and reference. This spirit existed among the members of the teaching faculty and among the school administrators as well. In a minor number of instances incomplete communication concerning the purposes and plans of the study prevented an adequately efficient operation. In one instance an apparent conflict within the administrative personnel of the school was reflected in a relatively low level of interest and cooperation on the part of the faculty. However, with this one exception, there was a generally expressed appreciation by the school personnel for the opportunity to participate in the study.

(c) Use of teaching resources.

It was evident that the teachers enjoyed working with the equipment which was moved into the classrooms. They made little use of the apparatus while it was kept on display in the mobile laboratory. When teachers became familiar with the apparatus, much of it was borrowed for use in their classrooms and laboratories.

The teachers of both science and mathematics obviously enjoyed their opportunities to become acquainted with new teaching materials and equipment. The science teachers in particular were stimulated by the opportunity to make plans for improving their science facilities. In mathematics, however, the time limitations in the programming narrowed considerably the opportunities for the teachers to use certain of the many new teaching aids available in the mobile laboratory.

(d) Experience with closed-circuit television.

The desire of the teachers to try to teach through the use of closed-circuit television was not uniformly distributed with respect either to schools or to teachers within a school. While a general interest prevailed in the process of seeing television programs produced and used for educational purposes, the interest in trying television teaching varied considerably. At least one teacher taught by television in each school (except in one instance where illness prevented). In some schools interest was high and resulted in the preparation and presentation of several classes in both science and mathematics by means of television. This experience was seemingly very stimulating and satisfying to the teachers who elected it.

From the standpoint of efficiency of instruction, a serious question was raised as to whether closed-circuit television should have been included in the teaching resources. The Associate Director found that much time and energy were required to make ready for the television presentation each day. This problem persisted throughout the study in spite of the repetition of the program from school to school and despite having available the services of the engineer and the technical assistant. It was the judgment of the Associate Director that the time spent in readying the necessary apparatus and materials for television could hardly have been reduced. Some of the teachers, also, raised questions as to whether this approach to the curriculum was the most efficient and effective.

(e) Planning for mobile laboratory teaching.

The period for planning and preparation prior to instruction in the schools was considered to be too brief by the two persons who taught directly in the study. Various factors contributed to this situation. Among them were the extended period of negotiation prior to approval of the grant, the difficulty in acquiring a vehicle, an underestimate of the time necessary to select and make arrangements with the participating schools, the preparation of evaluation instruments, and inefficiency in devising and developing the instructional materials and apparatus. Some of the teachers, also, offered the judgment that the planning period had been too short.

The distribution of the time as related to planning was a subject of informal evaluation. The specialist in mathematics education found substantial value in the strengthening of the relationships between school mathematics and science as a result of this project. However, the planning of the curriculum seemed not to make adequate provision for achieving this relationship, nor was the time allotted to mathematics education in the program sufficient for this purpose.

Some of the teachers suggested that the distribution of the time used each day could have been improved. These teachers proposed that a greater amount of time should be devoted to laboratory work.

(f) The teaching staff of the mobile laboratory.

The Associate Director found his duties numerous and time-consuming. He would have valued more administrative help. In spite of his own intensive preparation with respect to the topics in the academic fields included, he sensed that the contributions of several subject-field specialists would have been valuable if provision for the direct participation of such persons had been made. He recognized the difficulty in identifying such specialists who would have also the competence to work toward the solution of high school problems. Some of the teachers in the experimental schools, also, suggested that the availability of such subject-field specialists could have improved the program.

(g) The nature of the mobile laboratory.

The vehicle made available for the mobile laboratory, a converted school bus, was considered by all who were directly concerned to have been too small for the functions it served. The initial plan provided that it be largely self-contained, and that only the power source and the viewing room for the closed-circuit television be provided by the school. It is considered that a vehicle of the size and design of a moderate-sized (or larger) moving van would be much more satisfactory. Assuming the need for closed-circuit television in the study, the studio should be incorporated within the vehicle rather than having to be set up within the school.

XII. SUMMARY AND CONCLUSIONS

The amount of evidence bearing on the objectives of the study is extensive, as the presentation in the preceding section shows. The evidence ranges from the statistical to the informal. It bears on the specific objectives of the study and upon concomitant objectives of perhaps equal importance. Each of the stated objectives is repeated here, and a summary of the conclusions drawn with reference to the principal supporting evidence is given (the latter are grouped together for Objectives 3 and 4).

Objective 1. To produce and develop a Mobile Laboratory for the use of science and mathematics teachers in the improvement of their academic and professional competence.

Summary

The existence and use of a mobile laboratory in the in-service improvement of science and mathematics teachers is evidence that this approach is feasible from a physical standpoint. The critical finding is that the teachers were improved academically and, to a lesser extent, professionally. The evidence for this improvement is of both statistical nature, as shown by examinations (Section XI - A, 1), and qualitative as shown by the evaluations by the teachers of the curriculum (Section XI - A, 7(d)). The judgments of the school administrators support this evidence (Section XI - B, (d)), although they felt, as did many teachers, that not enough of current research in science and mathematics had been presented.

The mobile laboratory was less successful in improving the professional competence of the teachers. Only a trend could be identified statistically in relating the teachers' growth toward this, the first of the primary research objectives (Section XI - A, 3). However, the judgment of the teachers in their informal evaluation was that the research study had made them more aware of the possibilities of educational research, that they were stimulated to better classroom teaching, and to the use of experimental procedures in the classroom (Section XI - A, 7(b)). The judgment was offered that the academic content was overstressed at the expense of attention to professional teaching performance (Section XI - C, 5). The supervisors gave only very limited indication that they perceived professional growth in the teachers (Section XI - A, 4), whereas the school administrators were in agreement that general professional growth occurred (Section XI - B, (b) and (c)). Furthermore, there is evidence that the presence of the mobile laboratory in the school was reasonably well accepted (Section XI - A(e)) and even served to stimulate teachers not directly involved in the program (Section XI - D, (a)).

The general design of the curriculum was approved by the teachers (Section XI - A, 7(d)), although they would have preferred a more limited offering. They considered that a survey of the needs of teachers should be made in any comparable future project (Section XI - A, 7(e)).

The greater achievement in the academic phase of the curriculum than in the professional teaching field can be attributed to several factors. Among them are (1) a greater time emphasis on the subject matter component than on the teaching component, (2) a more rigidly defined and structured body of content in the subject matter component, (3) a greater need of subject matter help than of professional help by the teachers, and (4) a greater competence of the instructor in academic fields than in the professional teaching field.

Conclusions

It is evident that substantial progress was made in the development of a curriculum design for the improvement of in-service teachers of science and mathematics. This improvement was shown in two principal directions. The first of these was in bringing the content of science and mathematics into a more functional relationship with each other and with respect to the work of teachers in these fields. The second of these directions is that the subject matter and professional teaching components of the curriculum were placed in a more functional relationship with respect to each other. The wisdom of this aspect of the design and its promise for further fruitful study has been demonstrated.

The feasibility of a mobile laboratory has been established by the study. However, it should be observed that the results and interpretations herein reported may reflect the physical properties of the vehicle used. With respect to this point, the teachers did not consider, in general, that the conditions of presenting the program affected their attitude toward the study (Section XI - A, 7(e)). However, the Associate Director observed that the division of teaching resources between the mobile laboratory, parked at a distance from the school building, and the room provided for the study in that building, resulted in reduced teacher use of those resources located in the laboratory (Section XI-D(c)). A firm conclusion has been reached that comparable research studies in the future should have the service of a large vehicle, preferably of the moving-van type. This vehicle should be as nearly self-contained as possible, consistent with the plan for the study.

<ins>Objective 2</ins>. To develop procedures and techniques for the use of a mobile laboratory for science and mathematics teachers.

Summary

The fundamental idea behind the mobile laboratory and its over-all plan were reasonably promising, as attested by the general willingness of school administrators to have their schools serve as either experimental or reference schools. Various university faculty members cooperated in the design of the curriculum, striving particularly to achieve unity of purpose in the presentations. Those consultants who helped to select the schools, plan the evaluation program, and interpret the results, also directed their efforts toward the common purpose.

The evaluations of the teachers reflected a generally favorable attitude toward the over-all plan as an aid in adjustment to the changing times (Section XI - A, 7(b)). The efforts to project the University into the school by this procedure (reporting of research, and the like) were apparently only moderately well accomplished (Section XI - A, 7(b) and Section XI - C, 2). It can be postulated that the technical deficiencies and the difficulties in enunciation in one of the kinescopes reduced the value of this phase of the program to the teachers. A strong majority of the teachers would favor greater faculty participation in such a research project (Section XI - A, 7(e)). The school administrators considered, also, that this means of bringing current research to the school was not entirely effective (Section XI - D(d)). The Associate Director became convinced that the participation of a greater number of specialized personnel from the University would have made the program more effective (Section XI - D(f)).

Conclusions

With respect to the methodology of the program, it is evident that more time should have been given to general discussion and laboratory work (Section XI - 7(e)). (The relation of this outcome to program redesign is considered in the discussion concerning Objectives Three and Four.) This finding reconfirms a long-established principle in the teaching-learning process -- that the teaching situation should provide for the active involvement of the learner. The conviction that a greater number of specialists from the University should personally contribute may be in harmony with the expressed need for more time for discussion and laboratory work. The direct contributions of such persons may be considered as encouraging and providing for personal identification and involvement by the teacher-learner.

Objective 3. To determine the effectiveness of the instructional media in such a mobile laboratory.

Objective 4. To study the use of several media in a situation designed to cause each such medium or device to be part of a total presentation. Media and devices included such things as motion pictures, television,

> demonstrations, models, reading materials, commercial and hand-made apparatus, and the like. In this presentation, the object was to make the contribution of each medium or device relate to or be complementary to the contributions of other resources included in the mobile laboratory.

Summary

Objectives 3 and 4 are distinct, yet interrelated. The use of instructional media seems to be a very important, perhaps critical, factor in the teaching of science and mathematics. Much research is needed to determine with reasonable certainty whether the above stated objectives have been achieved.

The teachers considered that the apparatus and equipment in the mobile laboratory were moderately useful (Section XI - A, 7(b)). It was appropriate to high school use, although in some schools it was not greatly beyond the corresponding resources of the school. The Associate Director observed that the greater portion of the use of the apparatus resulted when it was removed from its display position in the mobile laboratory and made immediately accessible to the teacher (Section XI - B(c)). Furthermore, the use of teaching apparatus in the television presentations tended to prompt interest in and investigation of the uses of that apparatus during the laboratory time. Other apparatus on display and available for study was not equally used.

The school administrators valued the achievements of the teachers with respect to up-to-date techniques and materials, and in the production of hand-made resources (Section XI - B(b)).

The teachers considered that the "teaching aids," in contrast to laboratory and demonstration apparatus, were a more valuable aspect of the mobile laboratory (Section XI - A, 7(b)). Such aids included the contrived apparatus listed in Appendix C. However, this greater value may simply reflect a greater prior familiarity with the laboratory and demonstration apparatus than with the contrived apparatus.

The complementary contributions sought, as described in Objective 4, were apparently well achieved with respect both to the teaching aids, as identified above, and the films, slides, and charts. As with the teaching aids, a preponderant majority of the teachers considered that the visual materials were judiciously used (Section XI - A, 7(b)). While the mobile laboratory did not provide portable science and mathematics museums, or displays of that character, a similar majority responded favorably to the possibility of use of such devices.

The library of the mobile laboratory stimulated only a moderate request from the teachers to the school library for the purchase of books. The percentage of requests for equipment and teaching aids was somewhat greater (Section XI - A, 7(b)). However, these facts must be interpreted in the light of such factors as the needs of the school and the amount of funds available for this use within the period of study.

As described previously with reference to the methodology of the mobile laboratory program, it is evident that more time should have been given to general discussion and laboratory work (Section XI - 7(e)). Assuming that the time factors (three hours of instruction per day for a ten-day period) were satisfactory, with this assumption being supported by the teacher evaluation (Section XI - A, 7(a)), the alternative would seem to be to reduce the time devoted to television instruction. While the teachers valued the opportunity to see educational television programs produced (Section XI - A, 7(c)) and to produce and present their own teaching programs by television (Section XI -D(d)), they did not weigh the latter factor heavily (Section XI - A(c)). In fact, they compared television teaching unfavorably with the other media used in teaching (Section XI - A(c)) as did the Associate Director (Section XI - D(d)), who was the principal instructor. The teachers would not, in general, favor being required to teach science by television. This judgment may reflect their own difficulties in concentrating on the television presentations made by the Associate Director. They found it more difficult to concentrate on the television screen than on other media used in teaching (Section XI - A, 7(c)).

Conclusions

It is evident that both teachers and administrators considered that the instructional media were effectively used in the mobile laboratory. The evidence indicates that the teaching aids were considered more valuable than the laboratory and demonstration equipment, perhaps because of greater familiarity with the latter. It was evidently possible to achieve a relatively balanced program, with the various media complementing each other. However, the evidence suggests that the television portion of the program could have been reduced with profit in favor of a greater amount of individual laboratory work and general discussion.

Objective 5. To bring the presentations of science and mathematics in the mobile laboratory together in such ways as to teach the interrelationships of the academic areas included.

Summary

The curriculum of the mobile laboratory was designed, in both its content and methodological aspects, to serve Objective 5. The reasons for so doing were both philosophical and practical. If science and mathematics should be conceived as being common or one and the same, in the individual's intellectual resources, the curriculum should reflect that community of interest. From a practical standpoint, the presence of teachers of both science and mathematics in the class made the integration of the curricular materials of considerable importance.

2

The evidence is quite substantial that the teachers considered the program of value to teachers of mathematics, chemistry, physics, and biology (Section XI - A, 7(d)), although a minority indicated that they would have favored a curriculum limited to fewer fields. In the retrospective evaluation some teachers wondered whether it might have been more profitable to their individual interests if fewer fields had been included (Section XI - C, 2). The school administrators agreed, on the basis of their experience with the program, that the relationships of mathematics and science had been strengthened in the understandings of the teachers (Section XI - B (d)). It was the evaluative judgment of the specialist in mathematics education that progress had been made in integrating the two fields (Section XI - D (e)). The teachers considered, in their retrospective evaluation, that any such future research should attempt further to integrate science and mathematics (Section XI - C, 3).

Conclusions

There can be but little doubt that substantial progress was made toward achieving a closer relationship between mathematics and science in the curriculum designed for teachers in these fields. Not tested in this study, of course, were the means of developing the desire on the part of teachers to accomplish this end.

SPECIAL PROBLEMS

It is inevitable that a research study of this kind is confronted with special problems which may in either obvious or subtle ways affect the results achieved. A few of the problems encountered in this study are listed below.

1. Dependence upon the power supply of the school required that, in some schools, the mobile laboratory be parked in a relatively inaccessible location. The result was that, particularly in bad weather, the teachers tended not to use the resources inside the laboratory.
2. It was difficult to heat the mobile laboratory in very cold weather even with a separate heating unit. The low temperature inside discouraged its use by the teachers, and created undesirable working conditions, on occasion, for the engineer and the technical assistant.
3. During the spring months with warm weather it was difficult to dissipate the heat produced by the electronic apparatus. Again, working conditions inside the mobile laboratory were quite uncomfortable.
4. Because the television studio was set up within the school building in each instance, the amount of work required to unload and to reload the necessary equipment was considerable.

APPENDIX A

SCHEDULE OF THE MOBILE LABORATORY

SCHEDULE OF THE MOBILE LABORATORY

1959-1960

Experimental Schools

December 7-18	Newark High School
January 4-15	Defiance County High Schools
January 20 - February 2	Gallipolis High School
February 4-17	Dayton Belmont High Schools
February 24 - March 8	Canton Lincoln High School
March 10-22	Boardman High School
March 28 - April 8	Mentor High School
April 18-29	Morgan County High Schools

APPENDIX B

THE LIBRARY OF THE MOBILE LABORATORY

THE LIBRARY OF THE MOBILE LABORATORY

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APPENDIX C

APPARATUS AND SUPPLIES

Apparatus for Science and Mathematics Teaching

Air Sampler, High Volume
Ammeter
Animal Kingdom Collection
Aperture Attachment
Arc, Sodium
Atomic Model Kit
Balance, Triple Beam
Ballistics Car
Bell Jar
Bell in Vacuo
Bells, Xylophone
Bulb, Absorption
Burner, Gas
Burners, Alcohol
Caliper, Micrometer
Caliper, Vernier
Calorimeter
Camera Flash Attachment
Camera, Polaroid
Cathode Ray Tube
Chalkboards, Portable
Charts, Thermograph
Circle, Universal
Clamps, Extension
Coil, Induction
Collision Apparatus
Cone, Sphere, and Cylinder Kit
Crystals, Set of Model
Cylinder, Graduated
Dissection Set
D-Stix Set
Ear, Model of
Electroscope
Engine, Model
Eye, Model of
Filter Set, Optical, Color
Filter Sets, Opaque to Infrared
Filter Sets, Opaque to Visible
Filters, Polaroid
Fire Extinguisher
First Aid Cabinet
Friction Rods
Galvanometers
Gas Flow Counter
Gas Regulator
Geiger Tube
Geometric Construction Set
Geometric Solids and Surfaces
Graph Chart, Chalkboard Stencil
Gyroscope
Heater, Immersion
Inverse Square Device

Apparatus for Science and Mathematics Teaching (continued)

Jar, Hydrometer
Jars, Museum
Jars, Stoneware
Laboratory Demonstration Table, Mobile
Lamp, Mercury Vapor
Lamp, Optical Bench
Lens, Double Convex
Lens Holders
Letters, Display
Liter Case
Light Source, Mercury
Light Source, Universal
Magnets, Horseshoe
Manikin Kits, Physiological
Meter, Radio Frequency
Meter Sticks
Microtome
Milliammeter
Molecular Models, Organic
Optical Bench Supports
Optical Kits with Transmission Type and Reflecting Type Gratings
Pan, Dissection
Parallel Lines Device
Photocopier, Polaroid
Physiology Kit
Power Supply
Power Unit, Special
Preamplifier
Pump, Circulating
Pump, Force
Pump, Hand Compression
Pump, Plastic Lift
Pump, Vacuum
Pythagorean Theorem Model
Quadrilateral with Constant Midpoint
Radian and Circle
Receiver, Demonstration Radio
Reflectors, Parabolic
Resistance Box
Ring, Iron, for Ringstand
Ripple Tank
Scaler, Basic Decade and Probe
Sections, Hyperbolic
Sextant
Slide Rule
Spheres, Metal
Sprayer, Compressed Air
Symbols, Mathematical Display

Apparatus for Science and Mathematics Teaching (continued)

Thermometer, Max-Min.
Timer, Electrical
Top, Maxwell's
Torso, Human, Model of
Transmitter, Demonstration Radio
Triangle, Adjustable
Triangle with Constant Midpoint
Tripod, Camera
Trough, Pneumatic
Tube, Guinea and Feather
Tubes, Gas Dispersion
Tubes, Singing
Tubing Scorer, Glass
Tuning Forks, Set
Vibrator
Voltmeter
Wave Demonstrator, Spring

Suppliers and Equipment

Bearings, Incorporated 175 Cleveland Columbus, Ohio	Bearings and bearing race
Carter Products Company P. O. Box 1924 Columbus 16, Ohio	Flexible magnetic strips
Edmund Scientific Company Barrington New Jersey	Optical supplies
Fisher Scientific Company 711 Forbes Street Pittsburg 19, Pennsylvania	Scientific apparatus
General Metals Works Box 30 Cleves, Ohio	Air Sampler
William B. Johnson, Inc. P. O. Box 415 Mountain Lakes, New Jersey	Cloud chamber, electroscope, etc.
Nuclear Chicago 5775 North Ridge Avenue Chicago 26, Illinois	Scaler
Royal McBee Corporation Data Processing Division 362 West Broad Street Columbus, Ohio	Keysort Cards
E. H. Sargent Company 8560 West Chicago Avenue Detroit 4, Michigan	Scientific Apparatus
Sheldon Equipment Company Muskegon Michigan	Mobile Demonstration Apparatus
Star Band Company Broad and Commerce Streets Portsmouth, Virginia	Styrofoam Balls
Tecnifax Corporation 1292 West Third Street Columbus, Ohio	Photographic Paper
Tri-State Supply Company 720 Grandview Avenue Columbus 8, Ohio	Chalkboards and Bulletin Boards

Suppliers and Equipment (continued)

W. M. Welch Manufacturing 1515 Sedgwick Street Chicago 10, Illinois	Scientific Apparatus, audio-visual apparatus
Yoder Instruments East Palestine Ohio	Mathematical instruments and models

Contrived Apparatus and Other Unique Resources

Chalkboard-Display Unit -- A mobile, collapsible, structure fitted with steel chalkboard panels. Display space is provided by corkboard on reverse side of panels and map rail at the top.

Demonstration Stand -- A collapsible stand to provide additional area for demonstrations as needed.

Demonstration Table -- A mobile table equipped with pressure supplies for water and gas, and variable voltage supply of direct current.

Individual Chalkboards -- Separate steel painted chalkboards for individual use with such accessories as colored chalk, and mathematical, chemical, and physical symbols attached by means of magnetic tape.

Keysort Cards -- A proposed system of providing an inventory of school resources for science teaching.

Models of Atoms and Crystals -- Developed from Fisher-Hirschfelder-Taylor kits.

Models for Crystal Bonding -- Developed from D-Stix kits.

Timer for Free-fall Apparatus -- A hand-made unit.

Physics Kits -- Mounted lenses, reflection and transmission grating, light sources, and slit.

Rotating Table -- A "Lazy Susan" with a variety of uses in the laboratory and demonstrations

Styrofoam Balls -- With magnetic tape attached, the Styrofoam balls, in various colors, can be placed on steel chalkboard to represent such things as atoms and molecules.

Tecnifax Paper -- Of general use in science teaching, sensitive to ultraviolet light, it can be developed with the fumes from ammonium hydroxide.

APPENDIX D

AUDIO-VISUAL RESOURCES

Audio-Visual Resources

- Permanently Mounted Within the Mobile Laboratory
  - Motion Picture Projector
  - Slide Projector, 2"x2"
  - Tape Recorder and Playback

- Portable, for Use in Studio and Classroom
  - Camera, Polaroid
  - Charts
    - Electromagnetic Radiation
    - Electromagnetic Spectrum
    - Natural Disintegration of Atoms
    - Relative Sizes of Atoms
    - Structure of the Atom
  - Flash Cards, Atomic Energy
  - Motion Picture Films and Kinescopes
    - Effective Use of the Science Laboratory
    - Factors Influencing Chemical Reactions
    - Infra-red Radiation and Spectrophotometry
    - The Life Cycle of the Frog
    - Loop Film: Wave Motion
    - The Male Frog Pregnancy Test
    - Measuring Short Distances
    - The Millikan Oil Drop Experiment
  - Photocopier, Polaroid
  - Slides, Lantern
    - Handmade, statistical, and physical and biological science
    - Periodic Chart Slides
  - Television Camera
  - Television Receiver

APPENDIX E

Form DT -- SCIENCE AND MATHEMATICS KNOWLEDGE INVENTORY

Form AT -- SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form ET -- ATTITUDE SCALE

Form H -- EVALUATION OF MOBILE LABORATORY BY TEACHERS

Form BST -- SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form I -- LOCAL TEACHER COMMITTEE ANALYSIS OF THE MOBILE LABORATORY RESEARCH PROJECT

Form CSU -- SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form F -- MOBILE LABORATORY EFFECTIVENESS

Form J -- LOCAL TEACHER COMMITTEE ANALYSIS BRIEFS

SCIENCE AND MATHEMATICS KNOWLEDGE INVENTORY

Form DT
Teacher's Form

DIRECTIONS - In the space provided on the answer sheet place the number of the phrase which best completes that statement.

1. Which of the following statements is incorrect?

   (1) Every year, some 200 billion tons of carbon goes through the photosynthetic process. (2) All oxygen in our atmosphere could have been generated by photosynthesis in 2000 years. (3) All known living organisms depend ultimately on the photosynthetic process for their energy. (4) If it were not constantly being replaced, photosynthesis would use up all gaseous and dissolved carbon dioxide in about 300 years.

2. Several pigments found in the leaves of green plants may be separated by paper chromatography. Which one of the following statements is most nearly correct?

   (1) All plant pigments are quite soluble in water. (2) Paper chromatography depends upon the process of osmosis. (3) To obtain good separation of the pigments on the paper, a mixture of polar and non-polar solvents should be used. (4) Chlorophylls A and B will not be separated as their rates of flow on the paper are the same.

3. Among the following statements concerning the separation of plant pigments by paper chromatography, only one is incorrect. Mark the incorrect item for your answer.

   (1) The plant pigments from green leaves may be dissolved in some alcohol or in acetone. (2) A small spot of concentrated pigment solution should be placed on the paper and its position marked with a graphite pencil line. (3) The spot should be kept moist until the solvent has reached its position on the paper. (4) The original spot of the pigment on the paper should be kept above the level of the solvent.

4. Which one of the following statements concerning photosynthesis is true?

   (1) Light energy is used directly in the fixation of carbon dioxide. (2) Ordinary chlorophyll molecules become "excited" by certain wave lengths of visible light. (3) The oxygen given off as a by-product of photosynthesis comes from the carbon dioxide. (4) Photolysis is the step in photosynthesis where energy from "excited" chlorophyll breaks down carbon dioxide into carbon and oxygen gas.

SCIENCE AND MATHEMATICS KNOWLEDGE INVENTORY

Form DT
Teacher's Form

5. Only one of the following statements about the chlorophyll pigments is true. Identify the true statement as your answer.

   (1) Chlorophyll absorbs the green wave-lengths of visible light and reflects other wave-lengths. (2) At the "center" of chlorophyll molecules a single atom of the metal calcium is found. (3) In most green plants the chlorophyll is dissolved in the cytoplasm of the cells. (4) Under ultra violet radiation, a chlorophyll solution will glow with a blood red color.

6. A vector quantity is by definition.

   (1) A quantity having both direction and magnitude. (2) A force. (3) Applicable only to a body which is not in motion. (4) An arrow dependent on an arbitrary scale.

7. When the polygon of forces properly constructed forms a closed figure, we can say that the body on which the forces are acting is:

   (1) At rest. (2) In a state of equilibrium. (3) In the center of the polygon. (4) Being accelerated.

8. The acceleration of a body:

   (1) Is a constant quantity in any given situation. (2) Is always equal to the ratio of force to mass. (3) Involves a change in velocity either in direction or in magnitude or in both. (4) Is equal to 32 ft/sec^2 or 980 cm/sec^2

9. In a perfectly elastic collision:

   (1) Only momentum is conserved. (2) Only mechanical energy is conserved. (3) Momentum is conserved, but mechanical energy is not conserved. (4) Mechanical energy is conserved, but momentum is not conserved.

10. In simple harmonic motion, energy is all potential when the vibrating particle is:

    (1) At center of equilibrium position. (2) At one end of its swing or with displacement equal to its amplitude. (3) Halfway between center and end of swing. (4) In no position of the cycle.

11. Interference phenomena in light indicate that light:

    (1) Waves are capable of being polarized. (2) Waves are transverse. (3) Is some sort of wave disturbance. (4) Is electromagnetic in character.

12. When visible light is emitted from an excited atomic system the:

    (1) Wave length of the light is usually smaller than the physical size of the atom. (2) Light is primarily emitted from the nucleus of the atom. (3) Light is primarily emitted from the atomic system. (4) Frequency of the light is independent of the atomic system.

13. In the spectrum of white light formed by a diffraction grating the:

    (1) Blue lies nearer the central image than the red. (2) Red lies nearer the central image than does the blue. (3) Spectrum appears on only one side of the central image. (4) Central image is red on its left edge, green at the center and violet on its right edge.

14. Which of the following conditions will not produce polarized light?

    (1) Light reflected from a highly polished aluminum surface. (2) Light passing through a smoke filled chamber. (3) Light which has passed through a doubly refracting quartz crystal. (4) Light passing through tourmaline crystals.

15. The theory of covalence assumes that:

    (1) A molecule is unsymmetrical. (2) There is an electrostatic force of attraction between oppositely charged ions. (3) An atom completes its stable structure of 8 electrons in its outer orbit by sharing electrons with another atom. (4) There is either a shortage or an excess of electrons on the atoms present.

16. Ionic lattices are formed:

    (1) In covalent linkage. (2) In metallic linkage. (3) With an excess of or a shortage of electrons from each atom. (4) Through sharing electrons.

17. Polymerization occurs by which of the following processes?

    (1) Substitution. (2) Saponification. (3) Condensation. (4) Degradation.

18. Chemistry that involves acid catylized reactions is said to involve:

(1) Polymers. (2) Covalence. (3) Protons. (4) Electrons.

19. Measurements (i.e., inch, foot, gallon, quart, etc.) are:

(1) Exact. (2) Approximations. (3) Based on an exact standard only. (4) Evaluations.

20. Statistics is becoming more closely related to:

(1) Trigonometry. (2) Geometry. (3) Probability. (4) Determinants.

21. A bag contains 5 red and 6 white balls. If we draw 4 balls in succession without replacement, what is the probability that two will be red and two will be white.

(1) 5/11 (2) 6/11 (3) 4/11 (4) 3/11.

22. The standard deviation is:

(1) $\sigma x = x_1^2 - x_2^2$ (2) $\sigma x = x_1^2 - x_2^2$ (3) $\sigma x_2^2 = x_1 - x_2$

(4) $\sigma x^2 = x_1^2 - x_2$

23. Half-thickness refers to the:

(1) Viscosity of a fluid tracer. (2) Gauge of a metal determined by radiation. (3) Penetration of a substance by radiation. (4) Ruling of a defraction grating.

24. A scintillation counter uses:

(1) Light emitted from a nuclear reaction with a crystal. (2) The ionization of a gas within a high potential chamber. (3) The ionization of a gas as it flows over a sample. (4) The type of gas employed to record radiation.

25. The Geiger plateau refers to the:

(1) Pulse height of radiation. (2) Relationship of the counting rate to voltage on Geiger tube. (3) Frequency of discharge of the Geiger tube. (4) Distribution of counts over a period of time.

SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form AT
Teacher's Form

Code No. _____

DIRECTIONS - Please read the following directions carefully before attempting to rate the items.

This scale consists of 35 statements each of which pertains to some aspect of teaching methods. After reading through all 35 of the statements in order to be aware of their nature, you are to react to the statements in these three ways:

I. First, you are to rate each statement in terms of how ideal it is in your judgment as a teaching method or aspect of a teaching method. The rating for each statement is to be placed in the first column to the right of the statements under the heading "Ideal"; the following scale is to be used for this rating of the statements:

1.- deserves no consideration as an aspect of teaching method

2.- is of little importance as an aspect of teaching method

3.- is of moderate, or average, importance

4.- is quite important

5.- is of highest importance

II. Second, you are to rate each statement as to the amount of consideration you are able to give each method or aspect in your teaching. These ratings are to be placed in the second column to the right of the statements under the heading "Self-evaluation"; the following scale is to be used for the self-evaluation column:

1.- you give this method no consideration

2.- you give this method little consideration

3.- you give this method moderate, or average, consideration

4.- you give this method much consideration

5.- you give this method highest consideration

SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form AT
Teacher's Form

Directions con't.

III. Third, you are to select from the 35 statements the 10 which you consider the most important for teachers of science and mathematics. The 10 statements which you decide are the most important are to be checked (✓) in the appropriate blank in the third column under the heading "Most important."

Be sure to check (✓) 10 and only 10 statements regardless of the rating given in Steps I and II and indicated in the first two columns following the statements.

Example

Sample items	Ideal	Self-evaluation	10 most Important
1. Students are taught how to take examinations.	1	1	
2. Students are required to use a workbook.	3	2	
3. Recent developments of the subject are emphasized.	5	4	✓

Interpretation:

The respondent has indicated the following by the above ratings and checkmark:

Item 1 deserves no consideration as an ideal teaching method; in his own teaching the respondent indicates that he given no consideration to this method.

Item 2 is of moderate, or average importance as a teaching method; however, the respondent gives this method but little consideration in his teaching.

Item 3 is of highest importance for teachers and the respondent states he gives this method much consideration; moreover, he rates it among the 10 most important for teachers of mathematics and science.

TEACHING METHODS AND TECHNIQUES

These sheets are so prepared that your answer sheet lines directly with the scale items

Scale Items

1. The teacher uses a variety of methods in his teaching.
2. Students are encouraged to think through problems in a scientific manner.
3. Students are encouraged to follow approved steps in their science and mathematics problem solving.
4. Assignments are explained clearly.
5. Demonstrations are planned to stimulate student thinking.
6. An adequate background in the subject is evident in the teacher's teaching.
7. Good discipline is maintained.
8. The teacher shows a personal interest in his students.
9. Stimulating field trip experiences are carried out.
10. Original problems, experiments, models, and apparatus are developed by the teacher.
11. Chalkboard illustrations made by the teacher are easy to follow and are well labeled.
12. The theory of the subject is closely related to everyday living.
13. The teacher seems enthusiastic about his subject.
14. Student preparation is adequate for advanced work.
15. The teacher encourages frequent use of books, references, and other source materials.
16. Emphasis is placed on careful and detailed work.
17. The program is enriched through outside speakers.
18. Proper instruction is given in the use of source materials.
19. The teacher uses good scientific reasoning throughout the classroom experience.

TEACHING METHODS AND TECHNIQUES

These sheets are so prepared that your answer sheet lines directly with the scale items

Scale Items

20. Students are trained in good scientific observation, thinking, and reporting.

21. Student problems in understanding subject matter receive due consideration.

22. Course materials are adapted to individual interest and ability.

23. Grading (or marking) is just.

24. The program is enriched through the use of movies.

25. The class periods are well planned.

26. The classroom program takes advantage of world-wide resources.

27. Individual help is given when needed.

28. The teacher is an effective speaker.

29. Effective use is made of bulletin board materials.

30. Students are permitted to familiarize themselves with laboratory equipment by working with it both individually and in groups.

31. Students are encouraged to theorize from factual data.

32. Thought beyond the material assigned is encouraged, but is kept relevant to the discussion.

33. Students are encouraged to solve problems by more than one method.

34. Students are encouraged to think beyond the basic mechanics of a problem.

35. Estimation of answers is encouraged before problem solving is begun.

ATTITUDE SCALE

Form ET
Teacher's Form Code No.____

This portion of the evaluation is designed to determine the general feeling that teachers may have toward teaching.

DIRECTIONS: Answer these statements on this form. Use the Scale below. Place the number of the scale items in the box to the right of each statement.

Scale items:

1. strongly disagree
2. disagree
3. undecided
4. agree
5. strongly agree

Example:

0. Teachers like pupils ---------------------------------- 4

00. Pupils like teachers ---------------------------------- 3

* * * * * * * * *

Complete the form as indicated by the example:

1. I enjoy reading and learning about the subjects I teach. ------
2. The psychological atmosphere in which I work with my colleagues is very pleasant.-----------------------------------
3. Today there is little security in the teacher's job. ----------
4. Teaching offers the young person a fine opportunity to make the most of himself. ------------------------------------
5. Teaching provides an inadequate income in comparison with jobs in other fields. -----------------------------------
6. Working with young people is a stimulating career. ------------
7. The primary role of education is to train individuals to adjust themselves to the present environment. ----------------
8. Teaching interferes less than some occupations with a normal life. ---
9. The teacher has little opportunity to do much creative teaching. ---
10. The teacher performs a very useful service for society. -------

ATTITUDE SCALE

Form BT
Teacher's Form

11. The teacher must work unusually hard for his income. -----------

12. Teaching is an occupation of high prestige. -------------------

13. Personal satisfaction of a job well done is one valuable reward in teaching. --

14. Teaching is primarily an occupation for the conservative individual. --

15. There is a wide latitude of personal freedom afforded the teacher. --

16. School administrators frequently disregard their teachers' opinions. --------------------------------------

17. Long vacations are a source of real satisfaction for teachers.---

18. The selection of experiences for each pupil should be based on his interest and needs.-----------------------------

19. Teachers have contact with the great minds of their field.-------

20. The work of teachers is primarily to keep youngsters out of trouble.---

21. Most communities won't let a teacher lead his own personal life as he wishes.--

22. There is too much red tape and unnecessary time-consuming detail in the teaching profession.----------------------------

23. The administrators regard the teachers as subordinates rather than as colleagues. ----------------------------------

24. Teachers have little opportunity to participate in community life. ---

25. The physical conditions of the school plant indicate the attitude of the administration. ------------------------------

SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form BST
Student Form

DIRECTIONS -- Please read carefully the following directions.

On the following pages are 35 statements which pertain to teaching in general, but which may or may not describe the teaching in this course. After reading through all 35 of the statements in order to be aware of their nature, you are to react to the statements in these two ways:

1. First, you are to make a check mark (✓) in the True column for each statement which you think is generally true about this course; if you think the statement is generally untrue or false put the check mark (✓) in the False column. Since these materials are to be collected by a pupil in your room and taken directly to the Principal's office for forwarding to the Project Headquarters in Columbus, you may feel free to answer frankly for no one in your school will read your paper.

   Be sure that there is one, and only one, check mark for each item in the first two columns headed "True" and "False."

2. Second, you are to select from the 35 statements in the list the 10 to which you think your teacher gives the most consideration or emphasis. You are to indicate which statements you have selected by making a check mark (✓) in the appropriate blanks in the third column under the heading "Teacher Considers Most Important."

   Be sure to check (✓) 10 and only 10 statements in the last column.

EXAMPLE

	True	False	Teacher Considers Most Important
1. Students are taught how to take examinations.		✓	
2. Students are required to use a workbook.	✓		
3. Recent developments of the subject are emphasized.	✓		✓

SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form BST
Student Form

INTERPRETATION: The student who marked the three items has indicated the following by the above check marks:

Item 1 is marked False since the teacher does not spend time teaching students how to take examinations.

Item 2 is marked True since a workbook is required in the course for which the student is filling out the check list.

Item 3 also is marked True since the teacher does emphasize recent developments in the subject; moreover, the student has checked the final column also since the teacher gives much consideration and time to explaining to students new developments in the subject.

TEACHING METHODS AND TECHNIQUES

These sheets are so prepared that your answer sheet lines
directly with the scale items

Scale Items

1. The teacher uses a variety of methods in his teaching.

2. Students are encouraged to think through problems in a scientific manner.

3. Students are encouraged to follow approved steps in their science and mathematics problem solving.

4. Assignments are explained clearly.

5. Demonstrations are planned to stimulate student thinking.

6. An adequate background in the subject is evident in the teacher's teaching.

7. Good discipline is maintained.

8. The teacher shows a personal interest in his students.

9. Stimulating field trip experiences are carried out.

10. Original problems, experiments, models, and apparatus are developed by the teacher.

11. Chalkboard illustrations made by the teacher are easy to follow and are well labeled.

12. The theory of the subject is closely related to everyday living.

13. The teacher seems enthusiastic about his subject.

14. Student preparation is adequate for advanced work.

15. The teacher encourages frequent use of books, references, and other source materials.

16. Emphasis is placed on careful and detailed work.

17. The program is enriched through outside speakers.

18. Proper instruction is given in the use of source materials.

TEACHING METHODS AND TECHNIQUES

These sheets are so prepared that your answer sheet lines directly with the scale items

Scale Items

19. The teacher uses good scientific reasoning throughout the classroom experience.

20. Students are trained in good scientific observation, thinking, and reporting.

21. Student problems in understanding subject matter receive due consideration.

22. Course materials are adapted to individual interest and ability.

23. Grading (or marking) is just.

24. The program is enriched through the use of movies.

25. The class periods are well planned.

26. The classroom program takes advantage of world-wide resources.

27. Individual help is given when needed.

28. The teacher is an effective speaker.

30. Students are permitted to familiarize themselves with laboratory equipment by working with it both individually and in groups.

31. Students are encouraged to theorize from factual data.

32. Thought beyond the material assigned is encouraged, but is kept relevant to the discussion.

33. Students are encouraged to solve problems by more than one method.

34. Students are encouraged to think beyond the basic mechanics of a problem.

35. Estimation of answers is encouraged before problem solving is begun.

LOCAL TEACHER COMMITTEE ANALYSIS
# of the
MOBILE LABORATORY RESEARCH PROJECT

Form I

THE OHIO STATE UNIVERSITY
Bureau of Educational
Research and Service
Columbus 10, Ohio

RESEARCH IN SCIENCE AND
MATHEMATICS TEACHING

PURPOSE:

The purpose of the local meeting is to ascertain the thinking of the participating teachers in regard to several topics that pertain to the Research in Science and Mathematics Teaching Project.

PROCEDURE (to be used with each topic)

1. Refine the approach that may be used in future programs of this sort.
2. Formulate premises and thinking of the teacher participants.
3. Exchange ideas and information which may be a contribution to the total research program.
4. Illustrate any important ideas. Be certain explanations are clear.
5. Prepare a brief on the form provided of the discussion for relay of information to Columbus.

A twenty-five word brief should be prepared by the representative teacher on each of the six topics listed. Draw from the thinking of the group, using the procedure indicated above.

TOPICS:

1. The level of the academic work of the mobile laboratory
2. The development of school-university relationships
3. Appropriate objectives of such future research
4. Merits of the approach through instruction of teachers as compared with an approach through instruction of students
5. Degree of accomplishment of the objectives of this research project

OBJECTIVES:

1. To produce and develop a mobile laboratory for the use of science and mathematics teachers in the improvement of their academic and professional competence.

2. To develop procedures and techniques for use of a mobile laboratory for science and mathematics teachers.

3. To determine the effectiveness of instructional media in such a mobile laboratory.

4. To study the use of several media and devices in a situation designed to cause each such medium or device -- motion pictures, television, demonstrations, models, reading materials, and the like -- to be part of a total presentation. In this presentation, the object will be to make the contribution of each medium or device relate to or be complementary to the contribution of other resources included in the mobile laboratory.

5. To bring the presentations of science and mathematics in the mobile laboratory together in such ways as to teach their academic relationships.

SCIENCE-MATHEMATICS TEACHING METHODS AND TECHNIQUES SCALE

Form CSU

Supervisor's Form

DIRECTIONS - Please read the following directions carefully before attempting to rate the items.

This scale consists of 35 statements each of which pertains to some aspect of teaching methods. After reading through all 35 of the statements in order to be aware of their nature, you are to react to the statements in these two ways:

I. First, you are to rate each statement as to the amount of consideration the teacher named above gives to the item. The rating for each item is to be placed in the first column to the right of the statements under the heading "Teacher Evaluation" the following scale is to be used for this rating of the statements:

1 - The teacher gives this item no consideration

2 - The teacher gives this item little consideration

3 - The teacher gives this item moderate, or average consideration

4 - The teacher gives this item much consideration

5 - The teacher gives this item highest consideration

Be sure to rate every item in the column headed "Teacher Evaluation."

II. Second, you are to select from the 35 statements the 10 to which you believe this teacher gives the most consideration. The 10 statements which you select are to be checked (✓) in the appropriate blank in the second column under the heading "Most Consideration."

Be sure to check (✓) 10 and only 10 statements in the second column.

EXAMPLE

	Teacher Evaluation	Most Consideration
1. Students are taught how to take examinations.	1	

	Teacher Evaluation	Most Consideration
2. Students are required to use a workbook.	3	
3. Recent developments of the subject are emphasized.	4	✓

INTERPRETATION - The respondent has indicated the following by the above rating:

The teacher gives no consideration to teaching students to take examinations (Item 1); he gives moderate, or average, consideration to the use of workbooks (Item 2); and he gives much consideration to recent developments in the field (Item 3). Moreover, Item 3 is one of the ten most emphasized of the 35 items.

TEACHING METHODS AND TECHNIQUES

These sheets are prepared so that your answer sheet lines directly with the scale items

Scale Items

1. The teacher uses a variety of methods in his teaching.
2. Students are encouraged to think through problems in a scientific manner.
3. Students are encouraged to follow approved steps in their science and mathematics problem solving.
4. Assignments are explained clearly.
5. Demonstrations are planned to stimulate student thinking.
6. An adequate background in the subject is evident in the instructor's teaching.
7. Good discipline is maintained.
8. The teacher shows a personal interest in his students.
9. Stimulating field trip experiences are carried out.
10. Original problems, experiments, models, and apparatus are developed by the teacher.
11. Chalkboard illustrations made by the teacher are easy to follow and are well labeled.
12. Theory of the subject is closely related to everyday living.
13. The teacher seems enthusiastic about his subject.
14. Student preparation is adequate for advanced work.
15. The teacher encourages frequent use of books, references, and other source materials.
16. Emphasis is placed on careful and detailed work.
17. Program is enriched through outside speakers.
18. Proper instruction is given in the use of source materials.
19. The teacher uses good scientific reasoning throughout the classroom experience.

TEACHING METHODS AND TECHNIQUES

These sheets are prepared so that your answer sheet lines directly with the scale items

Scale Items

20. Students are trained in good scientific observation, thinking, and reporting.

21. Student problems in understanding subject matter receive due consideration.

22. Course materials are adapted to individual interest and ability.

23. Grading (or marking) is just.

24. Program is enriched through the use of movies.

25. Class periods are well planned.

26. The classroom program takes advantage of world-wide resources.

27. Individual help is given when needed.

28. The teacher is an effective speaker.

29. Effective use is made of bulletin board materials.

30. Students are permitted to familiarize themselves with laboratory equipment by working with it both individually or in groups.

31. Students are encouraged to theorize from factual data.

32. Thought beyond the material assigned is encouraged, but is kept relevant to the discussion.

33. Students are encouraged to solve problems by more than one method.

34. Students are encouraged to think beyond the basic mechanics of a problem.

35. Estimation of answers is encouraged before problem solving is begun.

THE OHIO STATE UNIVERSITY
Bureau of Educational Research and Service
Columbus 10, Ohio

RESEARCH IN SCIENCE AND MATHEMATICS TEACHING

EVALUATION OF MOBILE LABORATORY EFFECTIVENESS

The items in this evaluation are composed, in part, of statements which Ohio superintendents participating in this research program sent us before visitation of the mobile laboratory. These items were taken from a list of expected outcomes, which it was thought the unit should produce in each experimental school district. We would now like to know how well the mobile laboratory lived up to these expectations.

An administrator in the superintendent's office and the principal of the school in which the mobile laboratory was located are being asked to respond to this evaluation instrument. We appreciate your cooperation.

Sincerely yours,

T. Handley Diehl
Research Associate
Bureau of Educational
Research and Service

THD:gl

Enc.

MOBILE LABORATORY EFFECTIVENESS
Form F

The Ohio State University
Bureau of Educational Research
and Service
Columbus 10, Ohio

Research in Science and
Mathematics Teaching
in Secondary Schools

SCHOOL__________________________ NAME OF EVALUATOR______________________

DIRECTIONS: ANSWER these statements on this form. Use the scale below. Circle the number which best suits the reply you wish to give to each statement.

SCALE ITEMS:
1. Strongly Disagree
2. Disagree
3. Undecided
4. Agree
5. Strongly Agree

EXAMPLE:
0. Teachers like pupils 1 [✓ 2] 3 4 5
00. Pupils like teachers 1 2 3 [✓ 4] 5

* * *

Outcomes of the Mobile Laboratory

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1. It assisted teachers in the latest techniques available.	1	2	3	4	5
2. It assisted teachers in the latest materials available.	1	2	3	4	5
3. The TV was an "ice-breaker" for such work in the school of the future.	1	2	3	4	5
4. There was a certain amount of pride in being one of the schools selected.	1	2	3	4	5
5. It was a means of keeping teachers "abreast" of the times in other areas of teaching.	1	2	3	4	5
6. It was a means of keeping teachers "abreast" of the times in the science and mathematics areas.	1	2	3	4	5
7. It was a means for better understanding the the advantages and disadvantages of closed circuit television.	1	2	3	4	5

		Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
8.	It was an opportunity to take advantage of an up-to-date bibliography of reference material.	1	2	3	4	5
9.	It was an opportunity to acquaint teachers with modern trends in teaching techniques in science.	1	2	3	4	5
10.	It was an opportunity to acquaint teachers with modern trends in equipment in science.	1	2	3	4	5
11.	It was an opportunity to acquaint teachers with modern trends in teaching techniques in mathematics.	1	2	3	4	5
12.	It was an opportunity to acquaint teachers with modern trends in equipment in mathematics.	1	2	3	4	5
13.	It was a means to present the best teaching of science and mathematics to students for successful integration in future living.	1	2	3	4	5
14.	It was possible to obtain a critique on the present teaching efficiency as a result of this experiment.	1	2	3	4	5
15.	It aroused enthusiasm in the staff.	1	2	3	4	5
16.	It aroused enthusiasm in the students.	1	2	3	4	5
17.	It was hoped that over-all teacher performance could be improved.	1	2	3	4	5
18.	There was a definite public relations advantage to the school system.	1	2	3	4	5
19.	It was hoped that through this, the teacher would become aware that the administration is keenly interested in having the best possible job of instruction that is reasonable to expect.	1	2	3	4	5
20.	It was hoped that teachers would become familiar with new techniques that give reasonable promise of helping them do a better job.	1	2	3	4	5

		Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
21.	It was hoped that teachers would try new techniques that give reasonable promise of helping them do a better job.	1	2	3	4	5
22.	It was a means of ascertaining the amount of improvement of instruction that can be made through the use of TV or a mobile laboratory.	1	2	3	4	5
23.	It was a means of determining how teachers react to the TV tool or the mobile laboratory.	1	2	3	4	5
24.	It was a means of observing pupil reaction first-hand to the use of such a TV tool.	1	2	3	4	5
25.	It was a means of ascertaining what subject areas would receive the most benefit from such a mobile laboratory.	1	2	3	4	5
26.	It demonstrated what types of teachers get better results from these media.	1	2	3	4	5
27.	It was hoped to find where the maximum and minimums fall in terms of time per day and number of days per year in the use of this TV tool.	1	2	3	4	5
28.	It was hoped that the laboratory could give some idea of the possibility of obsolescence of TV in this age of rapid development.	1	2	3	4	5
29.	It was hoped that more students, because of the presence of the mobile laboratory, would be stimulated to enter the teaching profession.	1	2	3	4	5
30.	It was hoped that as a by-product, interest would spread to other areas in the high school staff.	1	2	3	4	5
31.	It was hoped that the laboratory would show an interrelationship between science and mathematics.	1	2	3	4	5
32.	It was hoped that the laboratory would provide an incentive for teachers to revitalize their course teaching.	1	2	3	4	5

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
33. It was expected that the laboratory should indicate to the teaching staff trends in educational research.	1	2	3	4	5
34. It was expected that the laboratory should make available to the teaching staff recent trends in educational research.	1	2	3	4	5
35. It was a means of developing an awareness in the school community for the need of a strong comprehensive science and mathematics program.	1	2	3	4	5
36. It was a means of developing an interest in science and mathematics areas for teachers.	1	2	3	4	5
37. It was a means of developing an interest in science and mathematics areas for students.	1	2	3	4	5
38. It was a means of developing an interest in science and mathematics for others in the community.	1	2	3	4	5
39. It was believed that the school should assume part of the professional responsibility of such a program.	1	2	3	4	5
40. It was hoped that the research would foster a better school-community relationship.	1	2	3	4	5
41. The mobile laboratory fostered better campus-school relationships.	1	2	3	4	5
42. Thirty hours of in-service training time with the teachers was sufficient.	1	2	3	4	5
43. The facilities of the University campus were made appropriately available through this method of field service.	1	2	3	4	5
44. Current research in science was made available to the science staff.	1	2	3	4	5

		Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
45.	Current research in mathematics was made available to the mathematics staff.	1	2	3	4	5
46.	There was a decided advantage to the participating school from the standpoint that professional educators were participants in the program.	1	2	3	4	5
47.	The mobile laboratory fostered better understanding between the classroom teacher and the professional educator.	1	2	3	4	5
48.	The laboratory was effective from the standpoint of presentations by demonstration.	1	2	3	4	5
49.	The display of available materials was an aid to the school district in judging the requests for purchase of science equipment.	1	2	3	4	5
50.	The mobile laboratory made available ideas on the preparation and the extent of use of homemade materials.	1	2	3	4	5
51.	There was good information on the preparation and use of teaching materials.	1	2	3	4	5
52.	There was available guidance in classroom skills.	1	2	3	4	5
53.	There was an opportunity for the teacher to become better acquainted with professional literature.	1	2	3	4	5
54.	It served as a means to acquaint teachers with the interrelationships of science and mathematics.	1	2	3	4	5
55.	The effective tool of demonstration techniques was effectively illustrated.	1	2	3	4	5
56.	The time students missed meeting with their regular science and mathematics teachers was compensated by the worth of the in-service program to the teacher.	1	2	3	4	5

		Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
57.	Finding substitutes for the teachers participating in the research program was not a major problem.	1	2	3	4	5
58.	The community responded favorably to the school's participation in educational research.	1	2	3	4	5
59.	The approach to the student via the teacher is of more lasting value than the approach to the student directly.	1	2	3	4	5
60.	In contrast to the approach of the mobile laboratory, a late after-school or evening program of concentrated in-service training is too tiring on most teachers for any real value to be realized.	1	2	3	4	5
61.	Through the use of films, charts and other devices, it was possible for one person to present the material adequately in the areas of chemistry, physics, mathematics and biology.	1	2	3	4	5
62.	The professional library in the mobile laboratory aided in the stimulation of academic growth.	1	2	3	4	5
63.	An awareness in the need for better communication in teaching was realized by the participating teachers.	1	2	3	4	5
64.	The opportunity to borrow materials from the mobile laboratory was one of its worthwhile functions.	1	2	3	4	5
65.	The teachers' general professional attitude was strengthened by the mobile laboratory work.	1	2	3	4	5

Please return your completed form PROMPTLY to : T. Handley Diehl, 288-B Arps Hall, 1945 North High Street, The Ohio State University, Columbus 10, Ohio.

LOCAL TEACHER COMMITTEE ANALYSIS BRIEFS

Form J

THE OHIO STATE UNIVERSITY
Bureau of Educational
Research and Service
Columbus 10, Ohio

RESEARCH IN SCIENCE AND
MATHEMATICS TEACHING

School______________________________Prepared by__________________________

DIRECTIONS: In the space provided below each topic, summarize in approximately 25 words, the thinking of the teachers from your school who participated in the research. Use Form I as a guide to the discussion.

TOPIC: The level of the academic work of the mobile laboratory.

The development of school-university relationships

Appropriate objectives of such future research

Merits of the approach through instruction of teachers as compared with an approach through instruction of students

Degree of accomplishment of the objectives of this research project

(Forward to Columbus no later than October 1, 1960 - Use the envelope provided.)

APPENDIX F

STATISTICAL INFORMATION AND OTHER EVIDENCE

THE CANTON PUBLIC SCHOOLS

Lincoln High School
2107 Sixth Street Southwest
Canton 6, Ohio

April 21, 1960

Mr. T. Handley Diehl
Ohio State University
288-B Arps Hall
1945 North High St.
Columbus 10, Ohio

Dear Mr. Diehl:

I would like to express my comments in regard to the Mathematics-Science project which was held at Lincoln High School the past month of February. We had nine teachers in our Math-Science area that were involved in the project and eight of these actually presented a TV broadcast. These individuals volunteered of their own free will and from their comments I know that they received a great deal of value from their preparation and presentation of their program. I feel that our entire faculty benefited because a majority saw these individuals on the TV monitor when they made their presentation. Their comments were very favorable because this was, for many of them, their first opportunity to see these teachers present a class demonstration.

This project has actually pulled our entire staff into a more closely knit unit and those teachers that were not involved in this project have taken a second look at some of their preparations and presentations, and have made favorable alterations in their own particular field. This project also meant a great deal of extra work for the teachers involved, but I was most pleased with their willingness to cooperate and make this project a success.

The student reaction was very good as the students made comments that they too could see the great amount of preparation that had to be made to present a 15 minute program on TV.

I am deeply appreciative to you and your staff for the opportunity to have our staff and school involved in this program. It has been quite a bit of added work but I feel that the benefits have made it very worthwhile.

Sincerely yours,

/s/ William Wolfarth

William Wolfarth
Principal

Table F-1

Assessed Valuation and Tax Rates for Experimental and Reference Schools

District Code	Assessed Valuation Per Pupil	School Tax Rates (in mills)		% of Total (All-purpose) Tax Rate Going To Schools
		Operating	Total	
A	$19,969	18.90	21.60	60
A'	20,342	18.92	20.30	63
B	16,144	16.10	20.40	70
B'	14,007	14.87	18.24	74
C	17,257	15.20	18.20	75
C'	13,930	17.00	21.10	73
D	17,575	11.50	13.70	64
D'	24,650	12.90	14.60	66
E	7,835	12.30	17.90	71
E'	9,625	13.60	17.30	64
F	10,413	12.00	13.50	51
F'	19,381	12.10	12.60	57
G	8,619	25.30	31.30	73
G'	9,819	18.80	20.90	66
H	12,724	13.65	19.30	70
H'	14,602	15.70	21.80	75
Average (experimental)	13,815.75	15.76	19.48	66.75
Average (reference)	15,794.50	15.48	18.35	67.62

Table F-2

School Expenditures and Salary Schedules for Experimental and Reference Schools

District	Expenditures Per Resident Pupil (1957-58)			Salary Schedule (1959-60)		
	Total	Instruction				
	Operation	Amount	% of Total	Minimum	Maximum	Spread
A	$351.94	$242.52	68.9	$3750	$7350	$3600
A'	359.68	254.59	70.8	4100	7350	3250
B	287.02	202.07	70.4	3400	6800	3400
B'	307.23	212.82	69.3	3900	6500	2600
C	312.07	224.92	72.1	3200	6100	2900
C'	304.65	218.60	71.8	3350	6450	3100
D	274.02	117.38	64.7	3000	5720	2720
D'	274.19	180.80	65.9	2600	5380	2780
E	217.96	158.11	72.5	3800	5000	1200
E'	247.90	179.74	72.5	3300	5000	1700
F	333.69	196.54	58.9	3000	5000	2000
F'	279.84	177.91	63.6	3300	5400	2100
G	360.81	248.71	68.9	3850	7000	3150
G'	265.84	178.45	67.1	3600	6400	2800
H	295.15	205.07	69.5	3300	5360	3150
H'	254.58	183.88	72.2	3250	6400	3150
Average (experimental)	304.08	206.91	68.23	3412.50	6041.25	2765.
Average (reference)	286.73	198.34	68.45	3425	6110	2685

Table F-3

Experimental School A: Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest Number of Participants	Pretest Sum of Raw Scores	Pretest Average Score	Posttest Number of Participants	Posttest Sum of Raw Scores	Posttest Average Score	Average Difference
AT-I	10	26	2.6	10	25	2.5	- 0.1
AT-II	10	22	2.2	10	17	1.7	- 0.5
AT-III	10	33	3.3	10	58	5.8	+ 2.5
BST-I	1262	3272	2.59	1252	3566	2.84	+ 0.25
BST-II	1262	2120	1.68	1252	2256	1.80	+ 0.12
BST-III	1262	4996	3.96	1252	5539	4.42	+ 0.46
CSU-I	11	35	3.18	11	37	3.36	+ 0.18
CSU-II	11	19	1.73	11	14	1.27	- 0.46
CSU-III	11	53	4.82	11	51	4.64	- 0.18
DT	10	74	7.4	11	104	9.4	+ 2.0
ET	10	880	88.0	11	937	85.18	- 2.82

Table F-4

Experimental School B : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	10	28	2.8	9	29	3.22	+ 0.42
AT-II	10	23	2.3	9	21	2.33	+ 0.03
AT-III	10	45	4.5	9	38	4.22	- 0.28
BST-I	1124	3377	3.0	1040	3018	2.90	- 0.1
BST-II	1124	2267	2.01	1040	2139	2.05	+ 0.04
BST-III	1124	5067	4.50	1040	4727	4.54	+ 0.04
CSU-I	9	19	2.11	10	28	2.80	+ 0.69
CSU-II	9	26	2.89	10	34	3.4	+ 0.51
CSU-III	9	34	3.78	10	40	4.0	+ 0.22
DT	10	82	8.2	9	95	10.55	+ 2.35
ET	10	844	84.4	8	700	87.50	+ 3.1

Table F-5

Experimental School C: Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	9	38	4.22	9	33	3.66	- 0.56
AT-II	9	15	1.67	9	22	2.44	+ 0.77
AT-III	9	38	4.22	9	35	3.89	- 0.33
BST-I	851	2567	3.01	789	2189	2.77	- 0.24
BST-II	851	1785	2.09	789	1584	2.00	- 0.09
BST-III	851	3732	4.38	789	3569	4.52	+ 0.14
CSU-I	9	28	3.11	9	27	3.0	- 0.11
CSU-II	9	29	3.22	9	21	2.33	- 0.89
CSU-III	9	34	3.78	9	42	4.67	+ 0.89
DT	9	65	7.22	9	98	10.88	+ 3.66
ET	9	725	80.55	9	738	82.0	+ 1.45

Table F-6

Experimental School D : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	9	27	3.00	7	22	3.14	+ 0.14
AT-II	9	19	2.11	7	12	1.71	- 0.40
AT-III	9	43	4.78	7	36	5.14	+ 0.36
BST-I	512	1364	2.66	502	1352	2.69	+ 0.03
BST-II	512	961	1.87	502	935	1.86	- 0.01
BST-III	512	2591	5.06	502	2495	4.97	- 0.09
CSD-I	9	24	2.66	9	21	2.33	- 0.33
CSD-II	9	16	1.78	9	16	1.78	± 0.0
CSD-III	9	50	5.56	9	44	4.89	- 0.67
DT	9	79	8.78	9	92	10.22	+ 1.44
ET	9	768	85.33	7	582	83.14	- 2.19

Table F-7

Experimental School E : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	5	15	3.0	5	18	3.60	+ 0.60
AT-II	5	9	1.80	5	11	2.20	+ 0.40
AT-III	5	26	5.20	5	21	4.20	- 1.0
BST-I	407	1242	3.05	385	1057	2.74	- 0.31
BST-II	407	825	2.02	385	780	2.02	± 0.0
BST-III	407	1714	4.21	385	1551	4.02	- 0.19
CSU-I	5	15	3.0	5	12	2.40	- 0.60
CSU-II	5	8	1.60	5	10	2.0	+ 0.40
CSU-III	5	27	5.40	5	28	5.60	+ 0.20
DT	5	53	10.60	5	65	13.0	+ 2.40
ET	5	433	86.60	5	444	88.8	+ 2.20

Table F-8

Experimental School F : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	3	8	2.66	3	14	4.66	+ 2.0
AT-II	3	5	1.66	3	7	2.33	+ 0.67
AT-III	3	17	5.66	3	9	3.0	- 2.66
BST-I	322	1045	3.20	275	797	2.90	- 0.30
BST-II	322	564	1.75	275	446	1.62	- 0.13
BST-III	322	1605	4.98	275	1501	5.45	+ 0.47
CSU-I	3	7	2.30	3	6	2.0	- 0.30
CSU-II	3	5	1.66	3	3	1.0	- 0.66
CSU-III	3	19	6.33	3	22	7.33	+ 1.0
DT	3	30	10.0	3	47	15.6	+ 5.60
ET	3	262	87.3	3	261	87.0	- 0.30

Table F-9

Experimental School G : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	12	26	2.16	9	18	2.0	- 0.16
AT-II	12	24	2.0	9	13	1.44	- 0.56
AT-III	12	69	5.75	9	49	5.44	- 0.31
BST-I	966	2265	2.34	807	2012	2.49	+ 0.15
BST-II	966	1811	1.87	807	1557	1.92	+ 0.05
BST-III	966	4332	4.48	807	3607	4.46	- 0.02
CSU-I	12	37	3.08	13	31	2.38	- 0.70
CSU-II	12	36	3.0	13	27	2.08	- 0.92
CSU-III	12	37	3.08	13	62	4.77	+ 1.69
DT	12	114	9.50	9	99	11.0	+ 1.50
ET	12	1009	84.0	9	748	83.1	- 0.90

Table F-10

Experimental School H : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	8	27	3.37	7	27	3.83	+ 0.46
AT-II	8	18	2.25	7	12	1.71	- 0.54
AT-III	8	35	4.38	7	31	4.43	+ 0.05
BST-I	806	2341	2.90	770	2169	2.82	- 0.08
BST-II	806	1851	2.29	770	1681	2.18	- 0.11
BST-III	806	3646	4.52	770	3504	4.55	+ 0.03
CSU-I	7	26	3.71	8	26	3.25	- 0.46
CSU-II	7	13	1.86	8	17	2.13	+ 0.27
CSU-III	7	31	4.43	8	36	4.0	- 0.43
DT	8	84	10.5	7	78	11.14	+ 0.64
ET	8	689	86.12	7	605	86.42	+ 0.30

Table F-11

Reference
~~Experimental~~ School A': Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	13	33	2.54	12	32	2.66	+ 0.12
AT-II	13	24	1.85	12	33	2.75	+ 0.90
AT-III	13	73	5.62	12	59	4.92	- 0.70
BST-I	764	2298	3.0	760	2487	3.27	+ 0.27
BST-II	764	1363	1.78	760	1446	1.90	+ 0.12
BST-III	764	3623	4.74	760	3472	4.56	- 0.18
CSU-I	13	39	3.00	13	28	2.15	- 0.85
CSU-II	13	37	2.85	13	50	4.85	+ 2.0
CSU-III	13	54	4.15	13	52	4.0	- 0.15
DT	13	109	8.38	12	98	8.16	- 0.22
ET	13	1067	82.07	12	990	82.50	+ 0.43

Table F-12

Reference School B': Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	7	26	3.70	6	21	3.50	- 0.20
AT-II	7	16	2.29	7	14	2.0	- 0.29
AT-III	7	28	4.0	7	29	4.14	+ 0.14
DST-I	824	2346	2.80	794	2447	3.10	+ 0.30
DST-II	824	1439	1.74	794	1387	1.74	± 0.0
DST-III	824	3535	4.29	794	3671	4.62	+ 0.33
CSU-I	7	19	2.70	7	19	2.70	± 0.0
CSU-II	7	28	4.0	7	18	2.57	- 1.43
CSU-III	7	23	3.29	7	33	4.71	+ 1.42
DT	7	61	8.70	6	57	9.50	+ 0.80
ET	7	602	86.0	6	498	83.0	- 3.0

Table F-13

Reference School C' : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	32	106	3.31	28	87	3.10	- 0.21
AT-II	32	61	1.91	28	68	2.43	+ 0.52
AT-III	32	163	5.09	28	124	4.43	- 0.66
BST-I	2481	7185	2.896	1799	5156	2.866	- 0.03
BST-II	2481	4805	1.93	1799	3480	1.93	± 0.0
BST-III	2481	11813	4.76	1799	8261	4.59	- 0.17
CSU-I	35	107	3.05	34	117	3.44	+ 0.39
CSU-II	35	65	1.86	34	97	2.85	+ 0.99
CSU-III	35	172	4.91	34	122	3.59	- 1.32
DT	31	293	9.45	28	303	10.82	+ 1.37
ET	32	2796	87.37	27	2329	86.25	- 1.12

Table F-14

Reference School D' : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	11	32	2.90	8	16	2.0	- 0.90
AT-II	11	11	1.0	8	16	2.0	+ 1.0
AT-III	11	67	6.10	8	43	5.38	- 0.72
BST-I	485	1526	3.14	313	778	2.48	- 0.66
BST-II	485	920	1.89	313	517	1.65	- 0.24
BST-III	485	2207	4.55	313	1348	4.30	- 0.25
CSU-I	5	10	2.0	9	25	2.78	+ 0.78
CSU-II	5	6	1.20	9	22	2.44	+ 1.24
CSU-III	5	29	5.80	9	63	7.0	+ 1.20
DT	10	92	9.20	9	80	8.89	- 0.31
ET	11	944	85.82	9	745	82.78	- 3.04

Table F-15

Reference School E': Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	9	28	3.10	8	24	3.0	- 0.10
AT-II	9	21	2.33	8	14	1.75	- 0.58
AT-III	9	41	4.56	8	42	5.25	+ 0.69
DST-I	640	1849	2.90	578	1569	2.70	- 0.20
DST-II	640	1177	1.84	578	1003	1.74	- 0.10
DST-III	640	3082	4.81	578	2488	4.30	- 0.51
CSU-I	9	30	3.30	9	26	2.90	- 0.40
CSU-II	9	12	1.33	9	22	2.44	+ 1.11
CSU-III	9	48	5.33	9	42	4.66	- 0.67
DT	9	94	10.4	8	79	9.90	- 0.50
ET	9	776	86.2	9	750	83.3	- 2.90

Table F-16

Reference School F': Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AS-I	9	28	3.11	9	30	3.33	+ 0.22
AS-II	9	16	1.77	9	13	1.44	- 0.33
AS-III	9	46	5.11	9	47	5.22	+ 0.11
SOT-I	489	1400	2.86	420	1176	2.80	- 0.06
SOT-II	489	958	1.96	420	760	1.81	- 0.15
SOT-III	489	2165	4.43	420	2039	4.85	+ 0.42
CBD-I	10	32	3.20	10	32	3.20	± 0.0
CBD-II	10	16	1.60	10	19	1.90	+ 0.30
CBD-III	10	46	4.60	10	39	3.90	- 0.70
BF	10	83	8.30	9	81	8.0	- 0.30
ST	10	823	82.3	9	773	85.9	+ 3.60

Table F-17

Reference School G' : Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	10	31	3.10	9	27	3.0	- 0.10
AT-II	10	21	2.10	9	22	2.66	+ 0.56
AT-III	10	48	4.80	9	43	4.77	- 0.03
BST-I	871	2416	2.77	788	2218	2.81	+ 0.04
BST-II	871	1702	1.95	788	1452	1.84	- 0.11
BST-III	871	4131	4.74	788	3592	4.55	- 0.19
CSU-I	10	35	3.50	10	28	2.80	- 0.70
CSU-II	10	20	2.0	10	20	2.0	± 0.0
CSU-III	10	46	4.60	10	52	5.20	+ 0.60
DT	10	101	10.1	9	92	10.22	+ 0.12
ET	9	746	82.88	9	734	81.55	- 1.33

Table F-18

Reference School N': Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	21	56	2.67	20	57	2.85	+ 0.18
AT-II	21	40	1.90	20	40	2.0	+ 0.10
AT-III	21	114	5.43	20	98	4.90	- 0.53
DST-I	2353	6900	2.93	2268	6727	2.97	+ 0.04
DST-II	2353	4726	2.01	2268	4404	1.94	- 0.07
DST-III	2353	10960	4.66	2268	10399	4.58	- 0.08
CSU-I	22	59	2.68	22	64	2.91	+ 0.23
CSU-II	22	52	2.36	22	65	2.95	+ 0.59
CSU-III	22	109	4.95	22	91	4.13	- 0.82
DT	21	175	8.33	18	168	9.33	+ 1.0
ET	21	1780	84.76	19	1617	85.1	+ 0.34

Table F-19

Experimental School I': Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	32	94	2.93	31	84	2.70	- 0.23
AT-II	32	48	1.50	31	52	1.68	+ 0.08
AT-III	32	171	5.34	31	163	5.26	- 0.08
BST-I	2940	8130	2.765	2591	6937	2.677	- 0.088
BST-II	2940	6292	2.14	2591	5477	2.11	- 0.03
BST-III	2940	12828	4.36	2591	10969	4.23	- 0.13
CSU-I	32	91	2.84	31	89	2.87	+ 0.03
CSU-II	32	70	2.19	31	72	2.32	+ 0.13
CSU-III	32	163	5.09	31	99	3.19	- 1.90
DT	32	330	10.31	31	330	10,64	+ 0.33
ET	32	2823	88.21	31	2687	86.67	- 1.54

Table F-20

Reference School J': Summary of numbers of participants, sums of raw scores, average scores, and differences between pretest and posttest average scores for all evaluation forms used.

Evaluation Form	Pretest			Posttest			Average Difference
	Number of Participants	Sum of Raw Scores	Average Score	Number of Participants	Sum of Raw Scores	Average Score	
AT-I	3	6	2.00	3	6	2.00	0
AT-II	3	9	3.00	3	9	3.00	0
AT-III	3	15	5.00	3	15	5.00	0
BST-I	308	802	2.60	291	775	2.66	+ 0.06
BST-II	308	630	2.04	291	574	1.97	- 0.07
BST-III	308	1512	4.90	291	1477	5.07	+ 0.17
CSU-I	3	6	2.00	3	8	2.66	+ 0.66
CSU-II	3	4	1.33	3	6	2.00	+ 0.67
CSU-III	3	20	6.66	3	15	5.00	- 1.66
DT	3	27	9.00	3	28	9.30	+ 0.30
ET	3	277	92.3	3	283	94.3	+ 2.00

Table F-21

Summary of Evaluation Results from Form AT-I for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	2.60	2.50	- 0.10	- 1	- 1
B	2.80	3.22	+ 0.42	+ 4	
C	4.22	3.66	- 0.56	- 6	- 6
D	3.00	3.14	+ 0.14	+ 2	
E	3.00	3.60	+ 0.60	+ 7	
F	2.66	4.66	+ 2.00	+8	
G	2.16	2.00	- 0.16	- 3	- 3
H	3.37	3.85	+ 0.48	+ 5	

T= 10

p= .1314

2p= .2628

Table F-22

Summary of Evaluation Results from Form AT-II for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign	
A	2.20	1.70	- 0.50	- 4		4
B	2.30	2.33	+ 0.03	+ 1	1	
C	1.67	2.44	+ 0.77	+ 8	8	
D	2.11	1.71	- 0.40	- 2.5		2.5
E	1.80	2.20	+ 0.40	+ 2.50	2.5	
F	1.66	2.33	+ 0.67	+ 7	7	
G	2.00	1.44	- 0.56	- 6		6
H	2.25	1.71	- 0.54	- 5		5
					T= 18.5	T=17.5

p= .4721

2p= .9442

Table F-23

Summary of Evaluation Results from Form AT-III for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	3.30	5.80	+ 2.50	+7	7
B	4.50	4.22	- 0.28	- 2	
C	4.22	3.89	- 0.33	- 4	
D	4.78	5.14	+ 0.36	+ 5	5
E	5.20	4.20	- 1.00	- 6	
F	5.66	3.00	- 2.66	- 8	
G	5.75	5.44	- 0.31	- 3	
H	4.38	4.43	+ 0.05	+ 1	1
					T= 13
					p= .2420
					2p= .4840

Table F-24

Summary of Evaluation Results from Form BST-I for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	2.59	2.84	+ 0.25	+ 6	6
B	3.00	2.90	- 0.10	- 3	
C	3.01	2.77	- 0.24	- 5	
D	2.66	2.69	+ 0.03	+ 1	1
E	3.05	2.74	- 0.31	- 8	
F	3.20	2.90	- 0.30	- 7	
G	2.34	2.49	+ 0.15	+ 4	4
H	2.90	2.82	- 0.08	- 2	

T= 11

p= .1635

2p= .3270

Table F-25

Summary of Evaluation Results from Form BST-II for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	1.68	1.80	+ 0.12	+ 6	6
B	2.01	2.05	+ 0.04	+ 2	2
C	2.09	2.00	- 0.09	- 4	
D	1.87	1.86	- 0.01	- 1	
E	2.02	2.02	0		
F	1.75	1.62	- 0.13	- 7	
G	1.87	1.92	+ 0.05	+ 3	3
H	2.29	2.18	- 0.11	-5	

T= 11

p= .1635

2p= .3270

Table F-26

Summary of Evaluation Results from Form BST-III for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	3.96	4.42	+ 0.46	+ 7	
B	4.50	4.54	+ 0.04	+ 3	
C	4.38	4.52	+ 0.14	+ 5	
D	5.06	4.97	- 0.09	- 4	4
E	4.21	4.02	- 0.19	- 6	6
F	4.98	5.45	+ 0.47	+ 8	
G	4.48	4.46	- 0.02	- 1	1
H	4.52	4.55	+ 0.03	+ 2	

T= 11

p= .1635

2p= .3270

Table F-27

Summary of Evaluation Results from Form CSU-I for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	3.18	3.36	+ 0.18	+ 2	2
B	2.11	2.80	+ 0.69	+ 7	7
C	3.11	3.00	- 0.11	- 1	
D	2.66	2.33	- 0.33	- 4	
E	3.00	2.40	- 0.60	- 6	
F	2.30	2.00	- 0.30	- 3	
G	3.08	2.38	- 0.70	- 8	
H	3.71	3.25	- 0.46	- 5	

T= 9

p= .1038

2p= .2076

Table F-28

Summary of Evaluation Results from Form CSU-II for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	1.73	1.27	- 0.46	- 3	
B	2.89	3.40	+ 0.51	+ 4	4
C	3.22	2.33	- 0.89	- 6	
D	1.78	1.78	0		
E	1.60	2.00	+ 0.40	+ 2	2
F	1.66	1.00	- 0.66	- 5	
G	3.00	2.08	- 0.92	- 7	
H	1.86	2.13	+ 0.27	+ 1	1

T= 7

p= .1190

2p= .2380

Table F-29

Summary of Evaluation Results from Form CSU-III for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	4.82	4.64	- 0.18	- 1	1
B	3.78	4.00	+ 0.22	+ 3	
C	3.78	4.67	+ 0.89	+ 6	
D	5.56	4.89	- 0.67	- 5	5
E	5.40	5.60	+ 0.20	+ 2	
F	6.33	7.33	+ 1.00	+ 7	
G	3.08	4.77	+ 1.69	+ 8	
H	4.43	4.00	- 0.43	- 4	4

T= 10

p= .1314

2p= .2628

Table F-30

Summary of Evaluation Results from Form DT for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A	7.40	9.40	+ 2.00	+ 4	
B	8.20	10.55	+ 2.35	+ 6	
C	7.22	10.88	+ 3.66	+ 7	
D	8.78	10.22	+ 1.44	+ 2	
E	10.60	13.00	+ 2.40	+ 5	
F	10.00	15.60	+ 5.60	+ 8	
G	9.50	11.00	+ 1.50	+ 3	
H	10.50	11.14	+ 0.64	+ 1	

$T = 0$

$p = .0059$

$2p = .0118$

Table F-31

Summary of Evaluation Results from Form ET for the Experimental Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign	
A	88.00	85.18	- 2.82	- 7		- 7
B	84.40	87.50	+ 3.10	+ 8	8	
C	80.55	82.00	+ 1.45	+ 4	4	
D	85.33	83.14	- 2.19	- 5		- 5
E	86.60	88.80	+ 2.20	+ 6	6	
F	87.30	87.00	- 0.30	- 1.50		- 1.5
G	84.00	83.10	- 0.90	- 3		- 3
H	86.12	86.42	+ 0.30	+ 1.50	1.5	
					T= 19.5	16.5
					p= .4168	
					2p= .8336	

Table F-32

Summary of Evaluation Results from Form AT-I for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A'	2.54	2.66	+ 0.12	+ 2	2
B'	3.70	3.50	- 0.20	- 4	
C'	3.31	3.10	- 0.21	- 5	
D'	2.90	2.00	- 0.90	- 7	
E'	3.10	3.00	- 0.10	- 1.5	
F'	3.11	3.33	+ 0.22	+ 6	6
G'	3.10	3.00	- 0.10	- 1.5	
H'	2.67	2.85	+ 0.18	+ 3	3

T= 11

p= .1635

2p= .3270

Table F-33

Summary of Evaluation Results from Form AT-II for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A '	1.85	2.75	+ 0.90	+ 7	
B '	2.29	2.00	- 0.29	- 2	2
C '	1.91	2.43	+ 0.52	+ 4	
D '	1.00	2.00	+ 1.00	+ 8	
E '	2.33	1.75	- 0.58	- 6	6
F '	1.77	1.44	- 0.33	- 3	3
G '	2.10	2.66	+ 0.56	+ 5	
H '	1.90	2.00	+ 0.10	+ 1	

T= 11

P= .1635

2P= .3270

Table F-34

Summary of Evaluation Results from Form AT-III for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A'	5.62	4.92	- 0.70	- 7	
B'	4.00	4.14	+ 0.14	+ 3	3
C'	5.09	4.43	- 0.66	- 5	
D'	6.10	5.38	- 0.72	- 8	
E'	4.56	5.25	+ 0.69	+ 6	6
F'	5.11	5.22	+ 0.11	+ 2	2
G'	4.80	4.77	- 0.03	- 1	
H'	5.43	4.90	- 0.53	- 4	

T= 11

p= .1635

2p= .3270

Table F-35

Summary of Evaluation Results from Form BST-I for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign	
A '	3.00	3.27	+ 0.27	+ 6	6	
B '	2.80	3.10	+ 0.30	+ 7	7	
C '	2.896	2.866	- 0.03	- 1		1
D '	3.14	2.48	- 0.66	- 8		8
E '	2.90	2.70	- 0.20	- 5		5
F '	2.84	2.80	- 0.04	- 3		3
G '	2.77	2.81	+ 0.04	+ 3	3	
H '	2.93	2.97	+ 0.04	+ 3	3	
					T= 19	17
					p= .4443	
					2p= .8886	

Table F-36

Summary of Evaluation Results from Form BST-II for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A'	1.78	1.90	+ 0.12	+ 4	4
B'	1.74	1.74	0		
C'	1.93	1.93	0		
D'	1.89	1.65	- 0.24	- 6	
E'	1.84	1.74	- 0.10	- 2	
F'	1.96	1.81	- 0.15	- 5	
G'	1.95	1.84	- 0.11	- 3	
H'	2.01	1.94	- 0.07	- 1	

T= 4

p= .0869

2p= .1738

Table F-37

Summary of Evaluation Results from Form BST-III for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A'	4.74	4.56	- 0.18	- 3	
B'	4.29	4.62	+ 0.33	+ 6	6
C'	4.76	4.59	- 0.17	- 2	
D'	4.55	4.30	- 0.25	- 5	
E'	4.81	4.30	- 0.51	- 8	
F'	4.43	4.85	+ 0.42	+ 7	7
G'	4.74	4.55	- 0.19	- 4	
H'	4.66	4.58	- 0.08	- 1	

T= 13

p= .2420

2p= .4840

Table F-38

Summary of Evaluation Results from Form CSU-I for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign	
A'	3.00	2.15	- 0.85	- 6	6	
B'	2.70	2.70	0			
C'	3.05	3.44	+ 0.39	+ 2		2
D'	2.00	2.78	+ 0.78	+ 5		5
E'	3.30	2.90	- 0.40	- 3	3	
F'	3.20	3.20	0			
G'	3.50	2.80	- 0.70	- 4	4	
H'	2.68	2.91	+ 0.23	+ 1		1

T= 13 8

p= .3015

2p= .6030

Table F-39

Summary of Evaluation Results from Form CSU-II for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A'	2.85	4.85	+ 2.00	+ 7	
B'	4.00	2.57	- 1.43	- 6	6
C'	1.86	2.85	+ 0.99	+ 3	
D'	1.20	2.44	+ 1.24	+ 5	
E'	1.33	2.44	+ 1.11	+ 4	
F'	1.60	1.90	+ 0.30	+ 1	
G'	2.00	2.00	0		
H'	2.36	2.95	+ 0.59	+ 2	

T= 6

p= .0886

2p= .1772

Table F-40

Summary of Evaluation Results from Form CSU-III for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A'	4.15	4.00	- 0.15	- 1	
B'	3.29	4.71	+ 1.42	+ 8	8
C'	4.91	3.59	- 1.32	- 7	
D'	5.80	7.00	+ 1.20	+ 6	6
E'	5.33	4.66	- 0.67	- 3	
F'	4.60	3.90	- 0.70	- 4	
G'	4.60	5.20	+ 0.60	+ 2	2
H'	4.95	4.13	- 0.82	- 5	

$T = 16$

$p = .3897$

$2p = .7794$

Table F-41

Summary of Evaluation Results from Form DT for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign	
A'	8.38	8.16	- 0.22	- 2		2
B'	8.70	9.50	+ 0.80	+ 6	6	
C'	9.45	10.82	+ 1.37	+ 8	8	
D'	9.20	8.89	- 0.31	- 3		3
E'	10.40	9.90	- 0.50	- 4.5		4.5
F'	8.50	8.00	- 0.50	- 4.5		4.5
G'	10.10	10.22	+ 0.12	+ 1	1	
H'	8.33	9.33	+ 1.00	+ 7	7	
					T= 22	14
					p= .2877	
					2p= .5754	

Table F-42

Summary of Evaluation Results from Form ET for the Reference Schools

School	Pretest Average Score	Posttest Average Score	Average Difference	Rank of Average Difference Regardless of Sign	Rank With Least Frequent Sign
A '	82.07	82.50	+ 0.43	+ 2	2
B '	86.00	83.00	- 3.00	- 6	
C '	87.37	86.25	- 1.12	- 3	
D '	85.82	82.78	- 3.04	- 7	
E '	86.20	83.30	- 2.90	- 5	
F '	82.50	85.90	+ 3.40	+ 8	8
G '	82.88	81.55	- 1.33	- 4	
H '	84.76	85.10	+ 0.34	+ 1	1

T= 11

P= .1635

2P= .3270

TABLE F-43

THE OHIO STATE UNIVERSITY
Bureau of Educational Research and Service
Columbus 10, Ohio

EVALUATION OF MOBILE LABORATORY BY TEACHERS
Form H

Name______________________________

School____________________________

RESEARCH IN SCIENCE AND
MATHEMATICS TEACHING

DIRECTIONS: Evaluate each of these statements in view of the way you now feel about the mobile laboratory research drawing on your experience with the study last year. Check each statement as to whether you agree or disagree.

TIME:		DISAGREE	AGREE
1.	Ten days was the right amount of time for an in-service training period in a school.	42%	55%
2.	Ten days was too much time for an in-service training period in a school.	75%	16%
3.	Ten days was not enough time for an in-service training period within a school.	58%	36%
4.	Three hours per day was too much time.	59%	39%
5.	Three hours per day was not enough time.	75%	13%
6.	Three hours per day was just about right.	34%	56%
OVER-ALL EFFECTIVENESS:			
7.	The mobile laboratory gave the participating teachers an awareness of the possibilities of educational research.	14%	84%
8.	As a teacher, the presence of the mobile laboratory encouraged me to try some ideas of my own (miniature educational research).	34%	64%
9.	The mobile laboratory stimulated me as a teacher to do a better job within my classroom.	27%	72%
10.	The mobile laboratory gave me new ideas in teaching approach.	33%	64%
11.	It brought a deeper realization of the relationship between science and mathematics.	48%	48%

		DISAGREE	AGREE
12.	It created a new zeal and enthusiasm for in-service programs related to a teacher's specific interest.	34%	62%
13.	The presence of the mobile laboratory made me, as a teacher, more aware of my role as a classroom teacher.	47%	47%
14.	Physical materials which could be borrowed from the mobile laboratory were an asset to my teaching.	47%	50%
15.	Physical materials which were available from the mobile laboratory were appropriate to the needs of the average high school laboratory.	33%	59%
16.	The tiring teaching day conflicted with the best interests of the program.	25%	73%
17.	Regular teaching duties subtracted from the best efforts that could be exerted toward such a program.	23%	73%
18.	It was a fine field-trip experience for the students in our school.	37%	58%
19.	The teaching aids presented made the understanding of the material easier.	28%	72%
20.	The teaching aids hindered the effectiveness of the program.	84%	9%
21.	In-service training via a mobile laboratory is a fine idea.	30%	64%
22.	There was sufficient time to browse on the mobile laboratory.	53%	47%
23.	The unit was an aid to adjustment of changing times.	22%	69%
24.	Judicious use of films, slides, and charts was generally well accomplished.	25%	72%
25.	The University was projected into the classroom through the visitation of the mobile laboratory.	50%	47%

	DISAGREE	AGREE
26. Teachers will be able to utilize the information for their classes which they received from the mobile laboratory.	45%	55%
27. A mobile laboratory for in-service education provides a good source of motivation for teachers.	34%	63%
28. As a result of my experience with the mobile laboratory I have requested a number of library books for professional use in our school.	77%	22%
29. As a result of my experience with the mobile laboratory, I have requested a number of materials (laboratory equipment, teaching aids, etc.) for use in our school.	64%	34%
30. Some of the ideas presented gave me good information which I may pass on to my students for possible science fair projects.	59%	34%
31. Some of the ideas presented gave me good information for use by the school science club. (If you do not have a science club, or are not actively engaged in science club activities, please do not answer this.)	16%	11%
VIA TV OR OTHERWISE:		
32. The television medium gave me an opportunity to evaluate it as a teaching device.	3%	97%
33. The opportunity to teach via television to my own classes was a decided asset.	56%	27%
34. It was easier to concentrate on the TV screen than by other media of communication in education.	86%	8%
35. It gave me an understanding of the problems of producing a good class recitation through this new medium.	12%	83%
36. It was easy to overcome the feeling of entertainment via TV and realize it as an educational tool.	36%	64%
37. It was not difficult to overcome the concept of the impersonal side of this new medium.	56%	34%

		DISAGREE	AGREE
38.	Teachers should have been required to participate in teaching their classes via TV.	67%	33%
39.	Science and mathematics museums should have been available so they could have been moved into the school during the mobile laboratory visitation.	28%	69%

COVERAGE OF INFORMATION:

		DISAGREE	AGREE
40.	The objectives of the program were clearly defined.	63%	36%
41.	The objectives were most obscure.	52%	40%
42.	As the mobile laboratory remained in our location, its objectives became more clearly defined.	40%	57%
43.	The scope of the program was too narrow for most purposes.	57%	39%
44.	The program should have had a more selective grouping in terms of subject matter approach.	14%	78%
45.	A preliminary orientation for the teachers is needed before the arrival of the mobile laboratory.	8%	92%
46.	The *general* level of academic work was too high.	47%	50%
47.	The *general* level of academic work was too low.	83%	5%
48.	The *general* level of academic work was about right.	44%	45%
49.	The level of work in my specific academic interest was on too high a plane.	64%	28%
50.	The level of work in my specific academic interest was on too low a plane.	78%	13%
51.	The level of work in my specific academic interest was about right.	37%	59%
52.	The general pace of the lecture-demonstration was too fast.	55%	37%

	DISAGREE	AGREE
53. The general pace of the lecture-demonstration was too slow.	80%	9%
54. The general pace of the lecture-demonstration was about right.	44%	55%

OTHER ASPECTS:

	DISAGREE	AGREE
55. Several resource people should be included in the program as an added stimulus to the program.	13%	85%
56. The program had some appeal to teachers of mathematics, chemistry, physics, and biology.	13%	85%
57. Clerical duties, such as grade reporting and attendance, substracted from the effectiveness of the program.	45%	50%
58. Pre-polling of school needs should be done.	8%	89%
59. Professional concepts of facilities were valuable.	30%	65%
60. More general discussion should have been provided for.	17%	83%
61. Direct provision should be made in such in-service programs for the students to participate by some means through their teachers.	14%	86%
62. The time involved in laboratory work should be increased.	30%	67%
63. Some provision should be made by the school for substitutes competent in the respective fields.	13%	85%
64. Some provision should have been made by the research project for competent substitutes during the program.	56%	39%
65. The type of room in my school in which the project was carried out definitely affected my attitude favorably toward the program.	67%	30%
66. The attitude toward the program was affected by the attitude of my principal.	56%	39%
67. The program should not involve a school later than May 1st.	6%	94%

		DISAGREE	AGREE
68.	The visitation of the mobile laboratory was a source of irritation among my colleagues who were not participating in the research.	77%	20%
69.	The basic thread of thought in the lecture was evident.	27%	69%
70.	The mobile laboratory made available ideas on the preparation and the extent of the use of homemade materials.	20%	80%

Return these forms to your representative who will forward them to the Associate Project Director, T. Handley Diehl, Bureau of Educational Research and Service, 288-B Arps Hall, 1945 North High Street, Columbus 10, Ohio.

Table F-44

Mobile Laboratory Effectiveness

Classification of Response and Summary of Evaluations for Form F

(a) General Effect on the Staff

Item Number	Expectations	Average
17.	It was hoped that over-all teacher performance could be improved.	4.55
19.	It was hoped that through this, the teachers would become aware that the administration is keenly interested in having the best possible job of instruction that is reasonable to expect.	4.27
30.	It was hoped that as a by-product, interest would spread to other areas in the high school staff.	4.22
32.	It was hoped that the laboratory would provide an incentive for teachers to revitalize their course teaching.	4.44
36.	It was a means of developing an interest in science and mathematics areas for teachers.	3.88
	Accomplished Results	
15.	It aroused enthusiasm in the staff.	3.50
47.	The mobile laboratory fostered better understanding between the classroom teacher and the professional educator.	3.50
63.	An awareness in the need for better communication in teaching was realized by the participating teachers.	3.88
65.	The teachers' general professional attitude was strengthened by the mobile laboratory work.	4.02

(b) Teaching Methods, Techniques, and Materials

Expectations

7.	It was a means for better understanding the advantages and disadvantages of closed circuit television.	4.27
20.	It was hoped that teachers would become familiar with new techniques that give reasonable promise of helping them do a better job.	4.38
21.	It was hoped that teachers would try new techniques that give reasonable promise of helping them do a better job.	4.50
22.	It was a means of ascertaining the amount of improvement of instruction that can be made through the use of TV or a mobile laboratory.	3.55
23.	It was a means of determining how teachers react to the TV tool or the mobile laboratory.	4.22
24.	It was a means of observing pupil reaction first-hand to the use of such a TV tool.	4.05
28.	It was hoped that the laboratory could give some idea of the possibility of obsolescence of TV in this age of rapid development.	3.16

Accomplished Results

1.	It assisted teachers in the latest techniques available.	4.22
2.	It assisted teachers in the latest materials available.	4.33
48.	The laboratory was effective from the standpoint of presentations by demonstration.	4.22
49.	The display of available materials was an aid to the school district in judging the requests for purchase of science equipment.	3.77
50.	The mobile laboratory made available ideas on the preparation and the extent of use of home-made materials.	4.00
51.	There was good information on the preparation and use of teaching materials.	3.77
52.	There was available guidance in classroom skills.	3.66
64.	The opportunity to borrow materials from the mobile laboratory was one of its worthwhile functions.	4.05

(c) Professional Contribution of the Mobile Laboratory

Expectations

8.	It was an opportunity to take advantage of an up-to-date bibliography of reference material.	4.27
9.	It was an opportunity to acquaint teachers with modern trends in teaching techniques in science.	4.22
10.	It was an opportunity to acquaint teachers with modern trends in equipment in science.	4.27
11.	It was an opportunity to acquaint teachers with modern trends in teaching techniques in mathematics.	4.00
12.	It was an opportunity to acquaint teachers with modern trends in equipment in mathematics.	4.05
34.	It was expected that the laboratory should make available to the teaching staff recent trends in educational research.	4.22
53.	There was an opportunity for the teacher to become better acquainted with professional literature.	4.05

Accomplished Results

3.	The TV was an "ice-breaker" for such work in the school of the future.	3.88
46.	There was a decided advantage to the participating school from the standpoint that professional educators were participants in the program.	4.11
47.	The mobile laboratory fostered better understanding between the classroom teacher and the professional educator.	3.50
62.	The professional library in the mobile laboratory aided in the stimulation of academic growth.	3.88
65.	The teachers' general professional attitude was strengthened by the mobile laboratory work.	4.02

(d) Scientific Contribution of the Mobile Laboratory

Expectations

6. It was a means of keeping teachers "abreast" of the times in the science and mathematics areas. 4.11

31. It was hoped that the laboratory would show an interrelationship between science and mathematics. 4.05

Accomplished Results

44. Current research in science was made available to the science staff. 3.83

45. Current research in mathematics was made available to the mathematics staff. 3.88

54. It served as a means to acquaint teachers with the interrelationships of science and mathematics. 4.00

(e) Instructional and Research Techniques of the Mobile Laboratory

Expectations

14. It was possible to obtain a critique on the present teaching efficiency as a result of this experiment. 3.33

25. It was a means of ascertaining what subject areas would receive the most benefit from such a mobile laboratory. 3.61

27. It was hoped to find where the maximums and minimums fall in terms of time per day and number of days per year in the use of this TV tool. 3.16

33. It was expected that the laboratory should indicate to the teaching staff trends in educational research. 4.38

Accomplished Results

26. It demonstrated what types of teachers get better results from these media. 3.83

42. Thirty hours of in-service training time with the teachers was sufficient. 3.00

44. Current research in science was made available to the science staff. 3.83

45. Current research in mathematics was made available to the mathematics staff. 3.88

61. Through the use of films, charts and other devices, it was possible for one person to present the material adequately in the areas of chemistry, physics, mathematics and biology. 3.27

(f) Effect of the Research Project on School-Community Relationships

Expectations

35. It was a means of developing an awareness in the school community for the need of a strong comprehensive science and mathematics program. 3.77

38. It was a means of developing an interest in science and mathematics for others in the community. 3.33

40. It was hoped that the research would foster a better school-community relationship. 4.05

Accomplished Results

4. There was a certain amount of pride in being one of the schools selected. 4.38

18. There was a definite public relations advantage to the school system. 4.27

58. The community responded favorably to the school's participation in educational research. 4.05

(g) Effect of the Research project on School-University Relationships

Expectations

39. It was believed that the school should assume part of the professional responsibility of such a program. 3.88

Accomplished Results

41. The mobile laboratory fostered better campus-school relationships. 3.66

43. The facilities of the University campus were made appropriately available through this method of field service. 3.66

(h) Effect of the Research Project on Pupils in the Experimental Schools

Expectations

29. It was hoped that more students, because of the presence of the mobile laboratory, would be stimulated to enter the teaching profession. 3.44

37. It was a means of developing an interest in science and mathematics areas for students. 3.88

Accomplished Results

16. It aroused enthusiasm in the students. 3.70

56. The time students missed meeting with their regular science and mathematics teachers was compensated by the worth of the in-service program to the teachers. 3.83

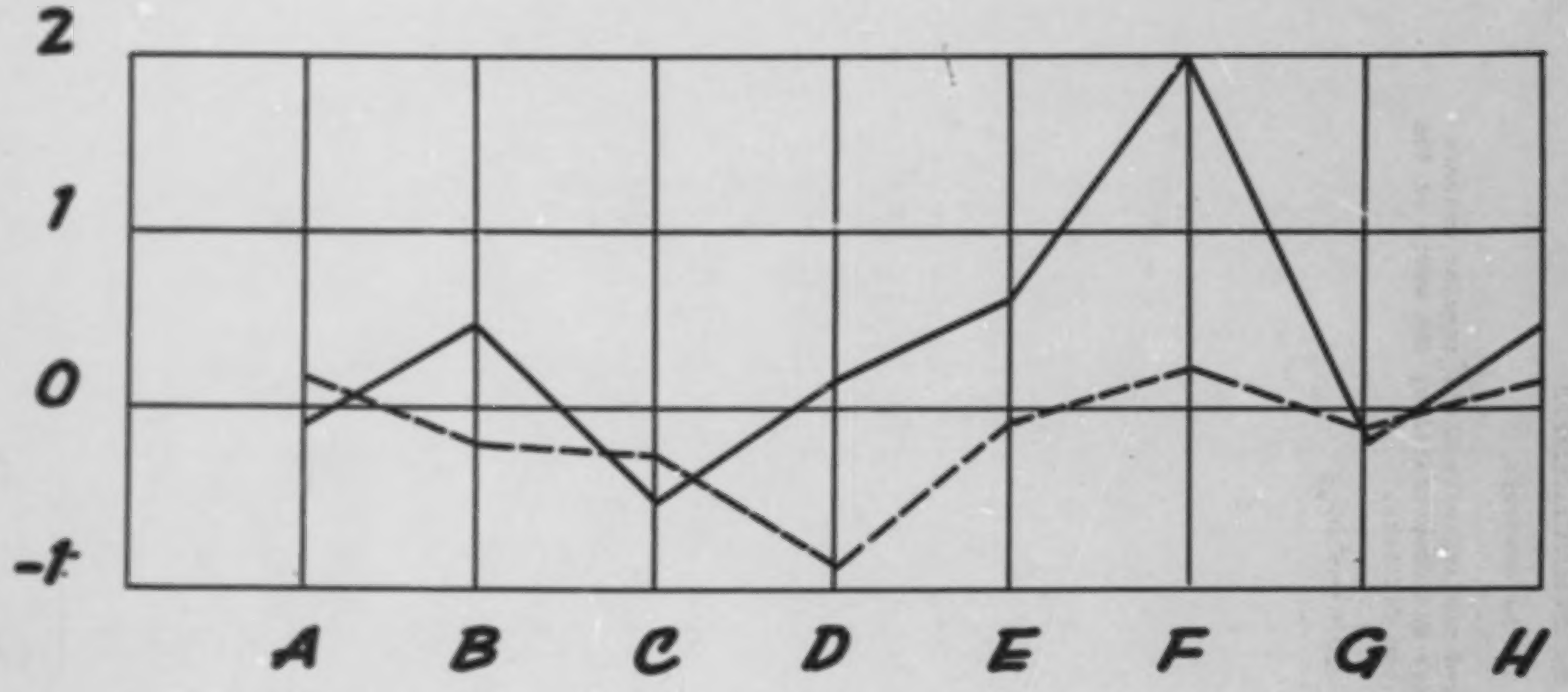


Figure F-1

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form AT-I.

- - - - - Reference Schools

________ Experimental Schools

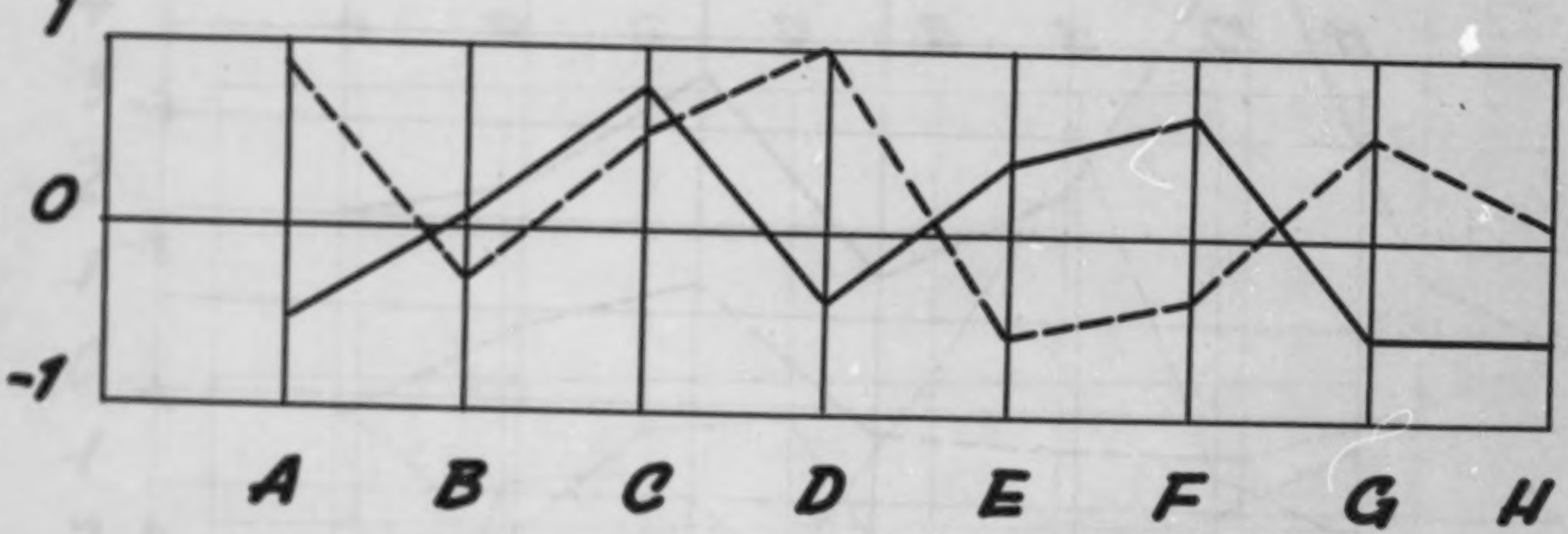


Figure F-2

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form AT-II.

- - - - - Reference Schools

________ Experimental Schools

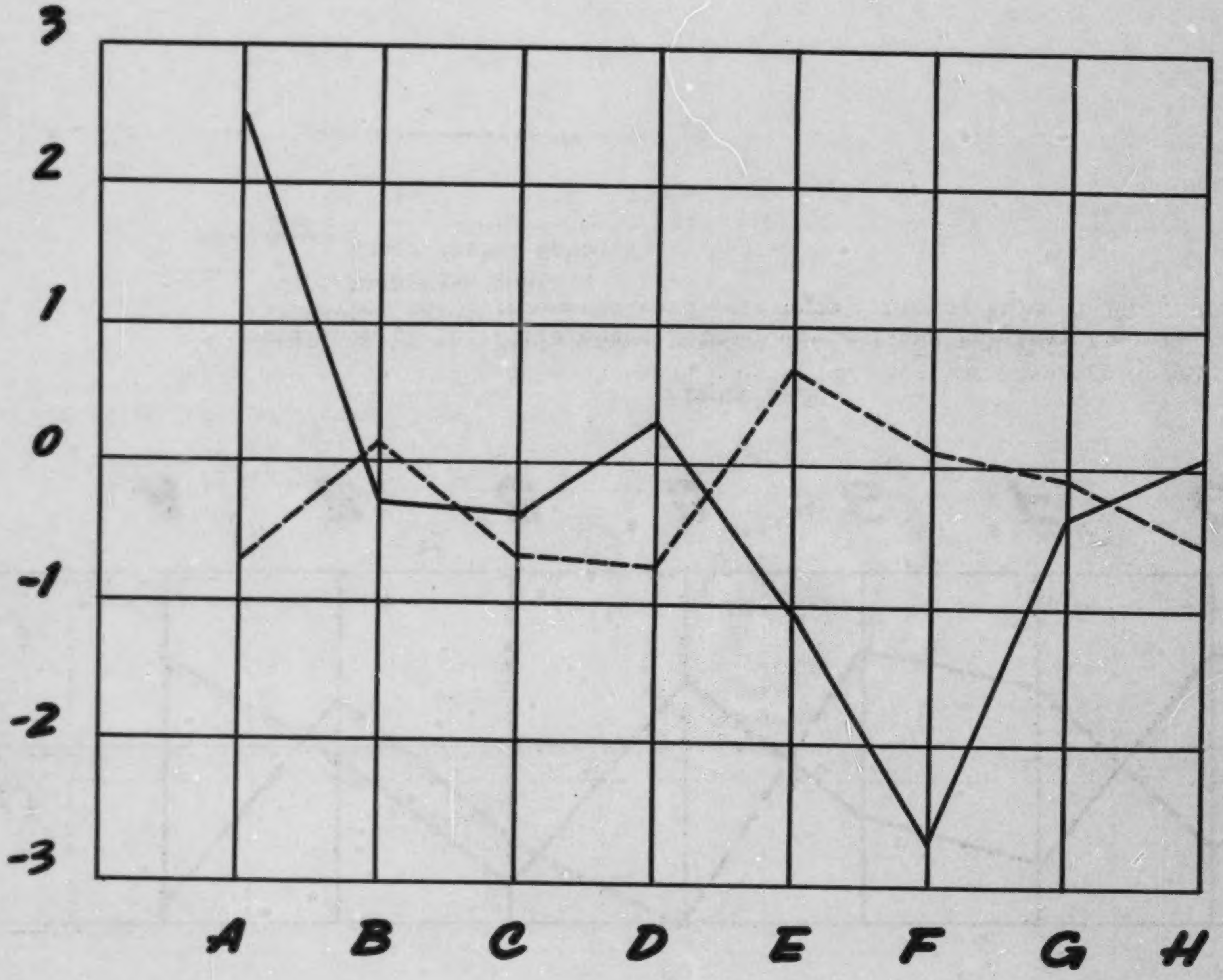


Figure F-3

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form AT-III.

- - - - - Reference Schools

________ Experimental Schools

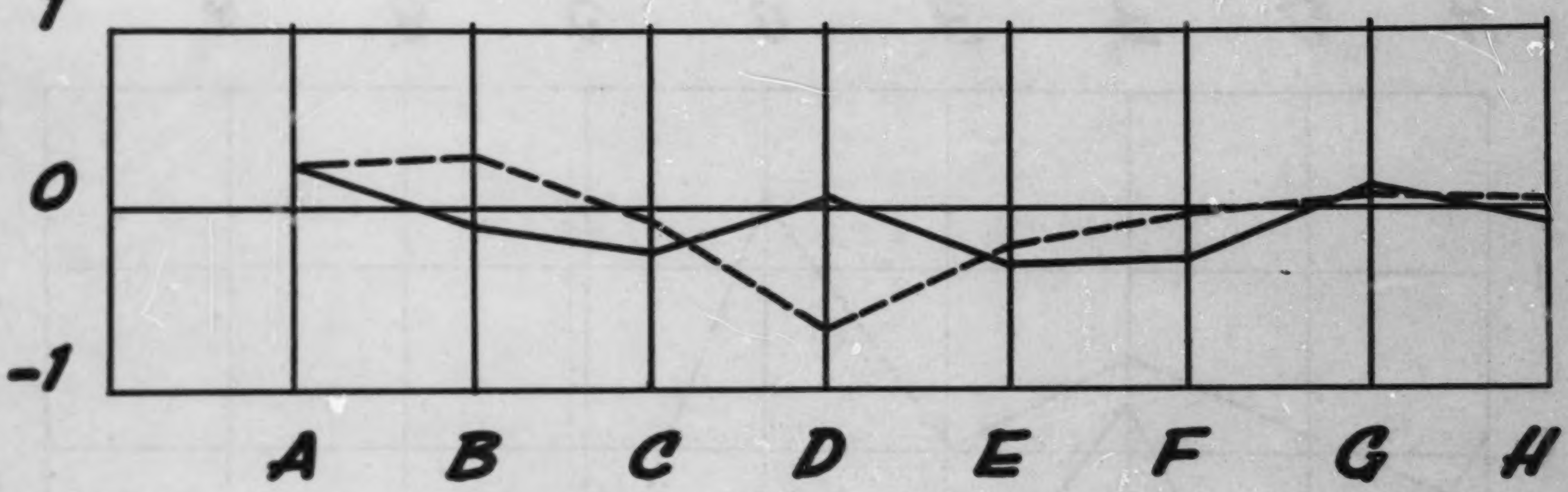


Figure F-4

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form BST-I.

- - - - - Reference Schools

________ Experimental Schools

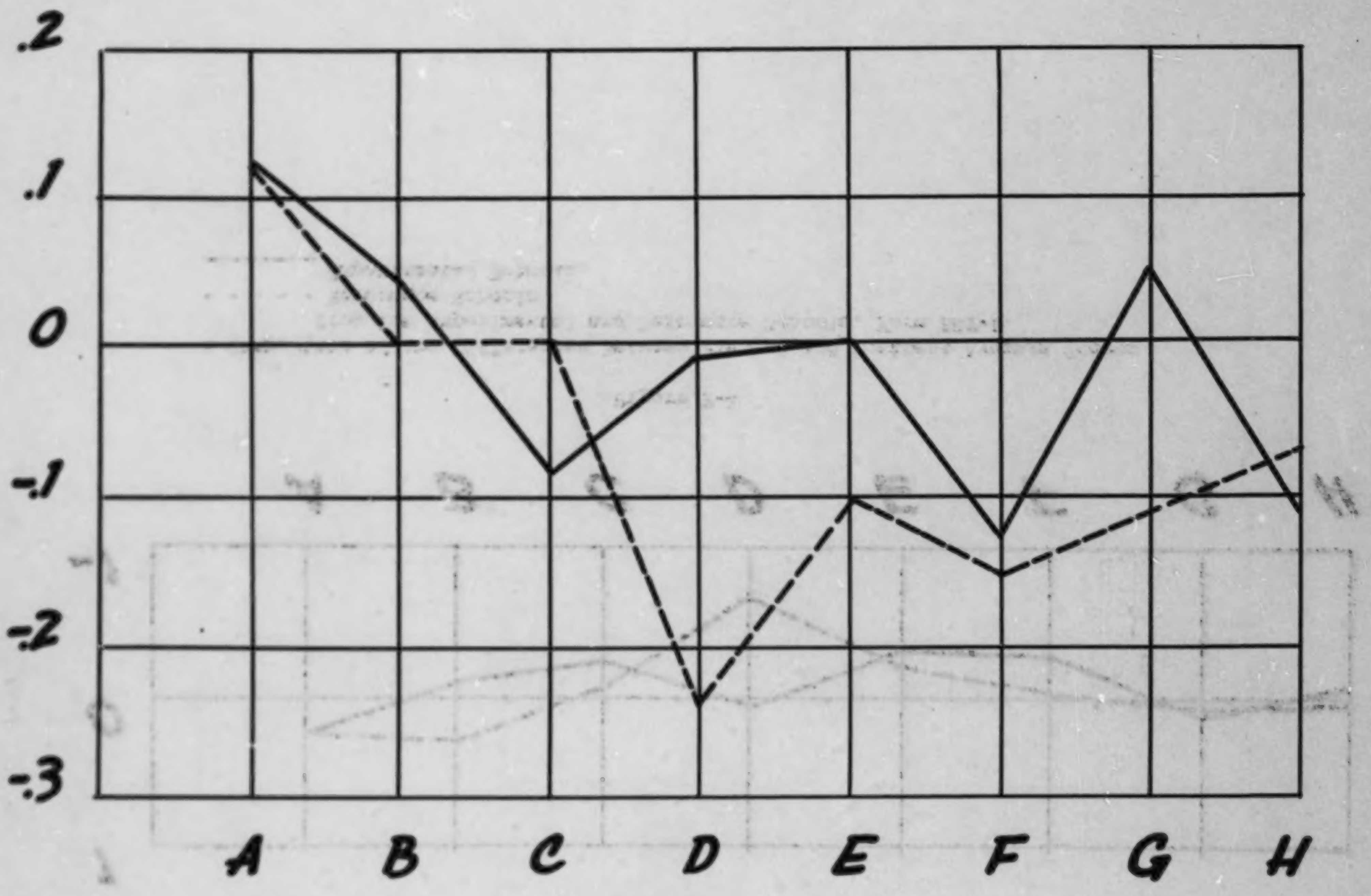


Figure F-5

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form BST-II.

- - - - - Reference Schools

________ Experimental Schools

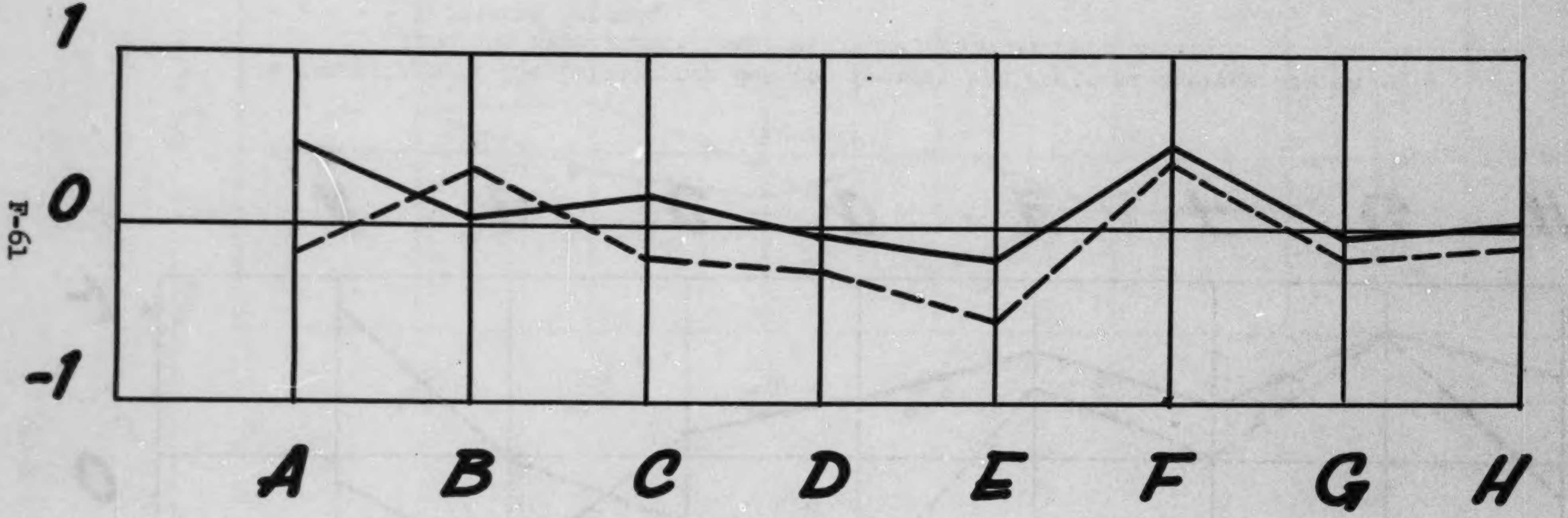


Figure F-6

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form BST-III.

- - - - - Reference Schools

_______ Experimental Schools

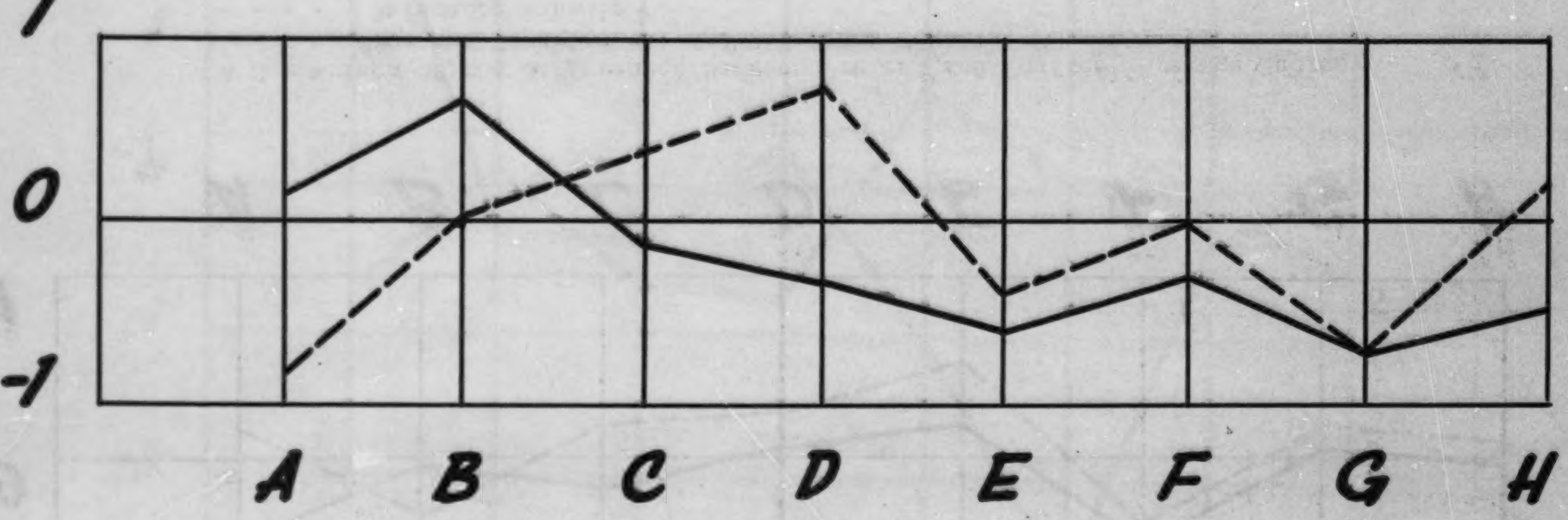


Figure F-7

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools; Form CSU-I.

- - - - - Reference Schools
________ Experimental Schools

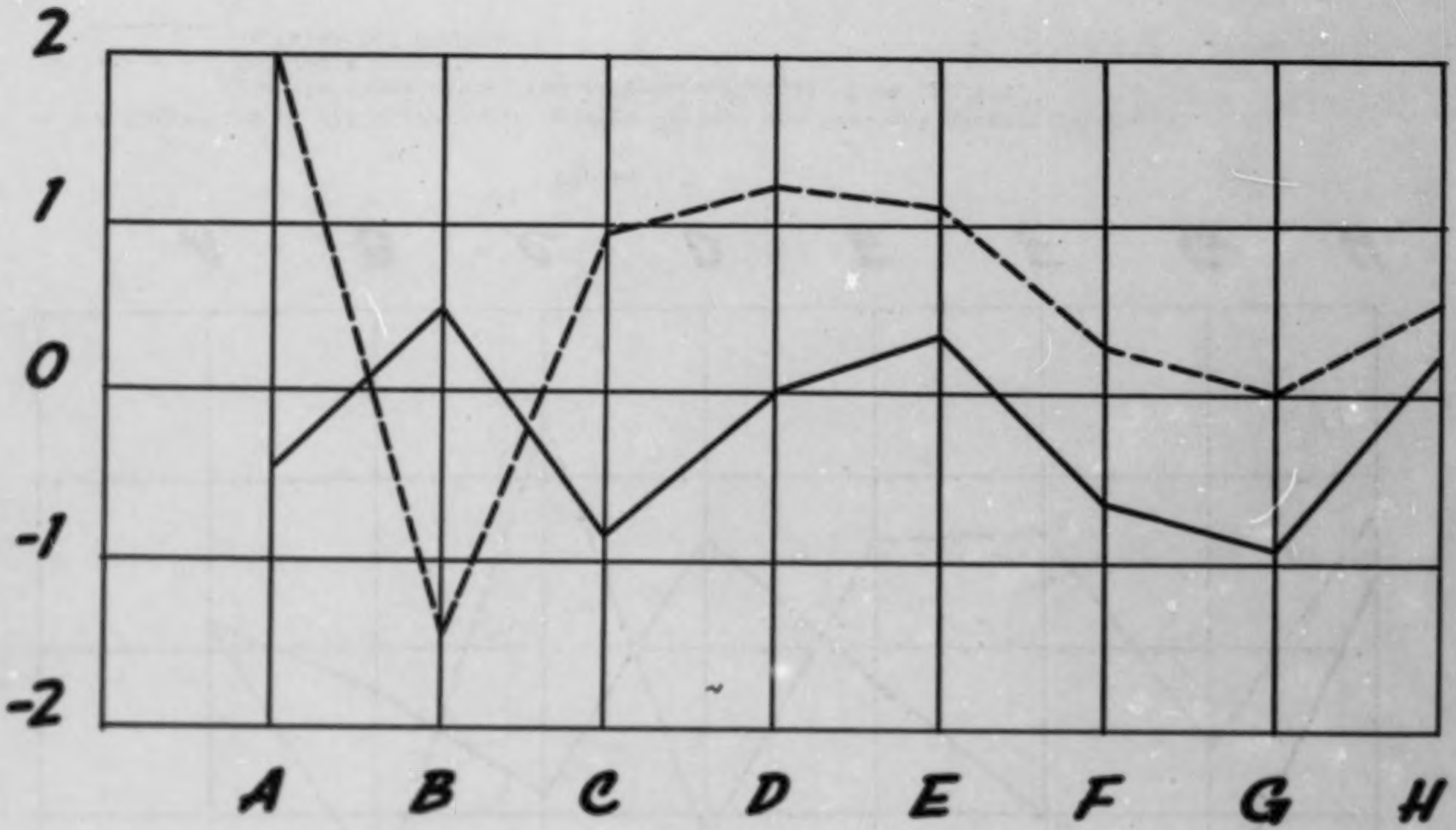


Figure F-8

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form CSU-II.

- - - - - Reference Schools

________ Experimental Schools

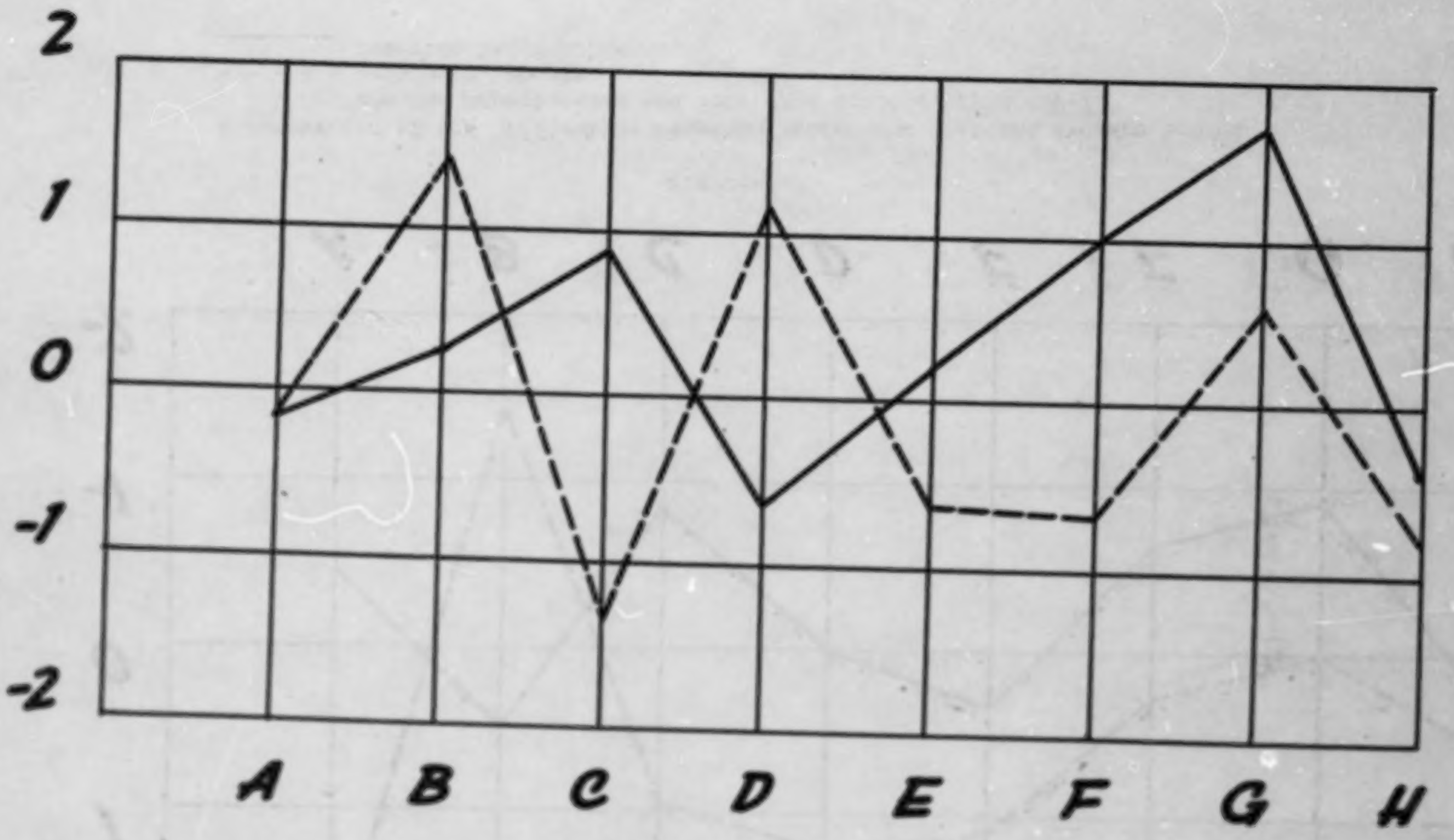


Figure F-9

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form CSU-III.

- - - - - Reference Schools

________ Experimental Schools

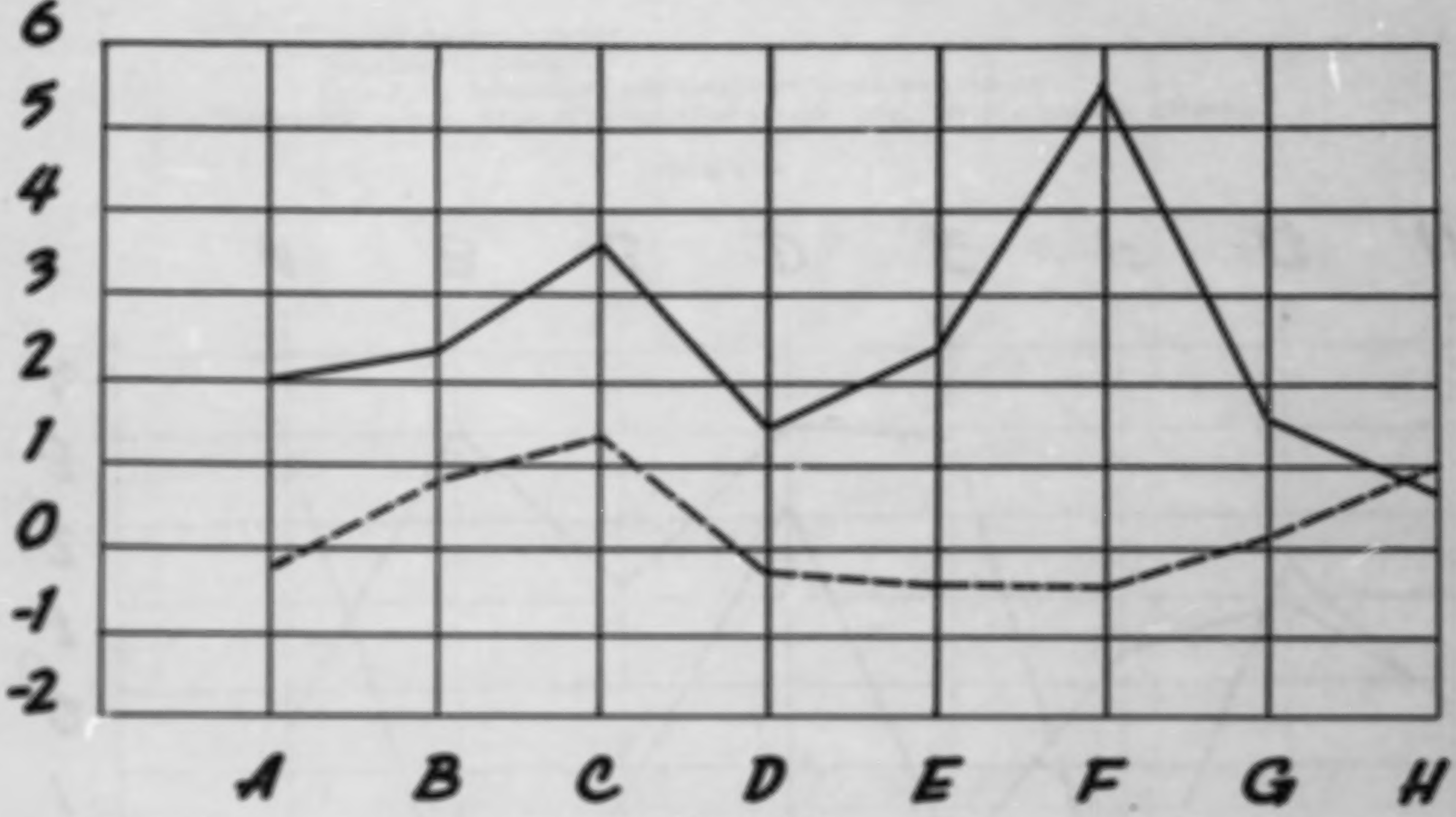


Figure F-10

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form DT.

- - - - - Reference Schools

________ Experimental Schools

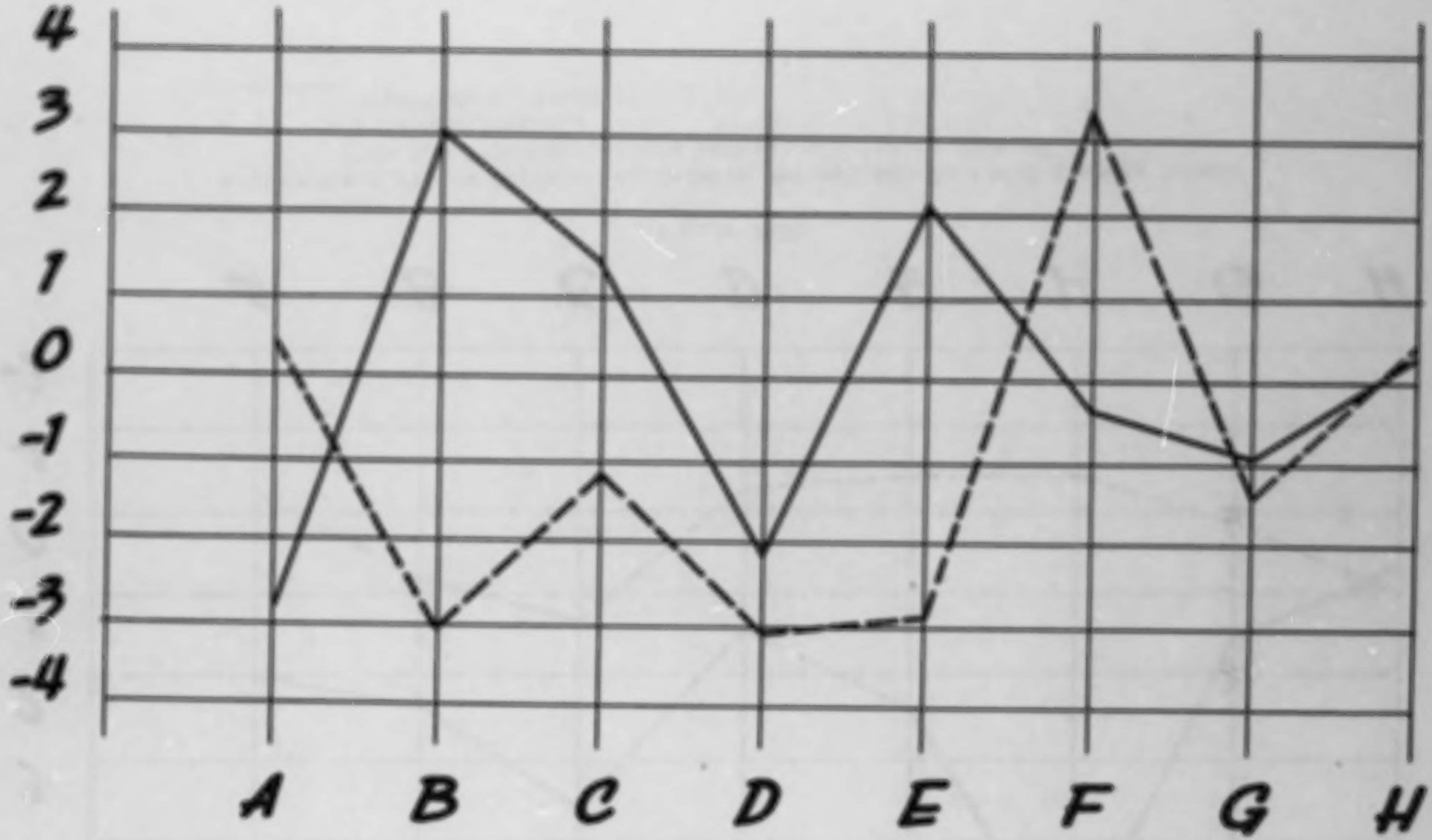


Figure F-11

A Comparison of the Differences Between Pretest and Posttest Average Scores from the Experimental and Reference Schools, Form ET.

- - - - - Reference Schools

________ Experimental Schools

APPENDIX G

LABORATORY EXPERIMENTS AND DEMONSTRATIONS FOR HIGH SCHOOL STUDENTS

Laboratory Experiment for possible use by high school physics students.

Purpose: To study the concept of acceleration

Materials: Revolving slotted wheel powered by 60 rpm synchronous motor
Sliding puck with battery and small light
Polaroid Land Camera

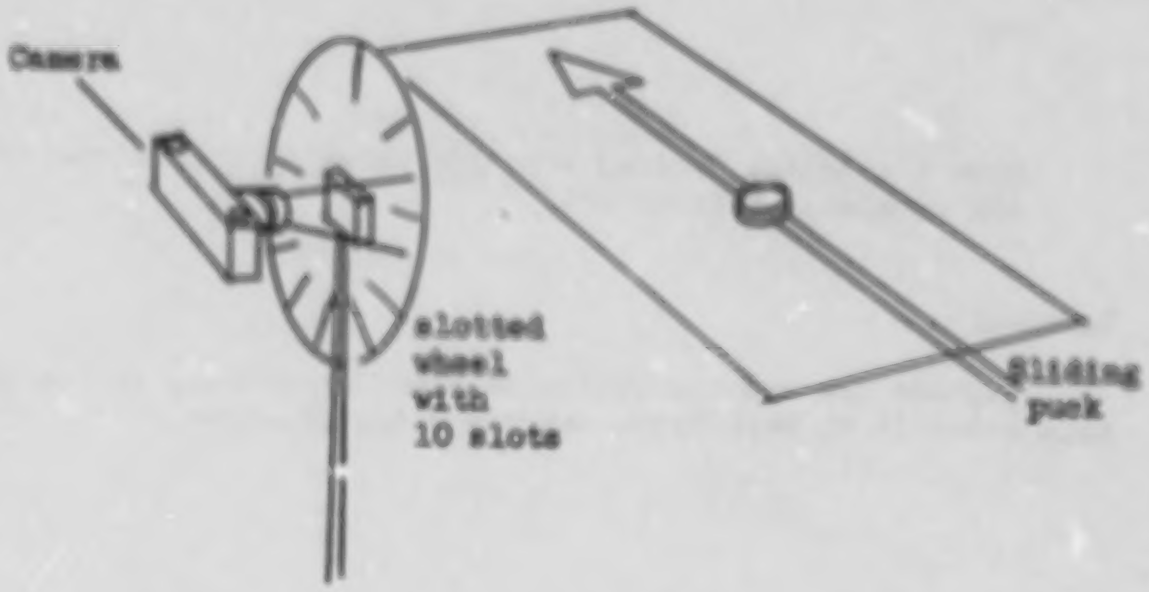
Procedure:

Set up the slotted wheel with the camera immediately behind the wheel.

Open the shutter of the camera and hold it open while the puck is slid in front of the wheel.

Close the shutter and develop the film.

Measure and plot the negative acceleration rate of the sliding puck.

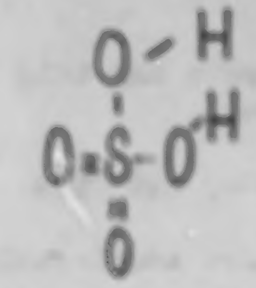


Purpose: To study some basic compounds and their reactions in relationship to their structure and their bonding.

Equipment: Styrofoam balls and chenille stems

Procedure:

Prepare a model of sulfuric acid from the diagram. Each oxygen atom (red) has two holes for valence bonds, each hydrogen atom (yellow) has one hole for its valence bond, and each sulfur atom (white) has six holes for its valence bonds.



Show ionic reaction with an alkali or an alkaline earth metal.

Show a covalent (redox) reaction in which copper reacts with the covalent sulfuric acid.

Discussion:

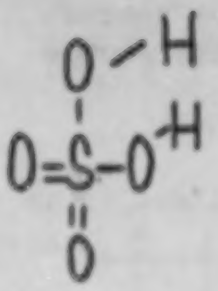
Explain the varying shifts in electron density in the sulfuric acid molecule to make these two reactions possible.

Purpose: To study the structure and reactions of molecules

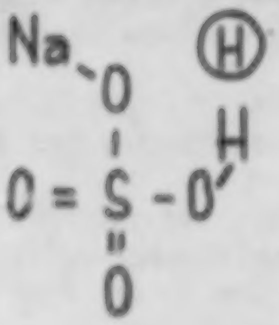
Materials: Commerical models or homemade styrofoam ball sets

Procedure:

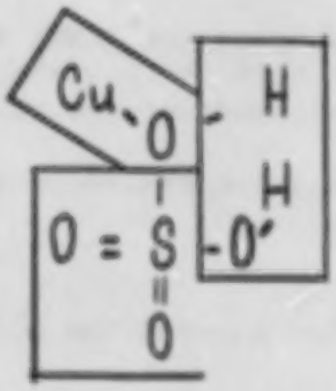
Prepare a model of the sulfuric acid molecule as shown in the diagram.



Show breaking of the hydrogen-oxygen bond in ionic reactions with an active metal. (Explain this is not entirely accurate in theory.)



Show the breaking of bonds of the covalent sulfuric acid with copper.



NOTE: Each of these models can be built either with the Sargent ball and stick models or with the Fisher-Herschfelder-Taylor atomic scale models.

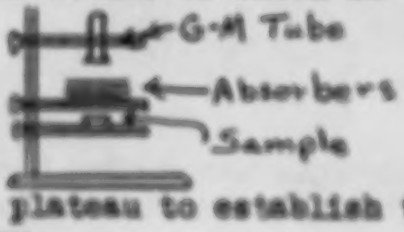
Purpose: To study the effects of absorber thickness

Equipment: G-M end window tube and scaler

Material:
30 or 40 2" squares of 1/32" cardboard
10 or 20 2" squares of aluminum foil
10 or 20 2" squares of copper foil
10 or 20 2" squares of lead foil
Beta radioactive source
Gamma radioactive source

Procedure:

1. Set up the G-M tube and scaler as shown in the diagram



2. Use the predetermined plateau to establish the operating voltage of your counter.
3. Determine the background count for the geometry of the system. (Background = count rate without sample present. Geometry = relationship of counter to the sample.)
4. Determine the count rate for the B-source and again after each cardboard square is added above the B-source.
5. Record your observations remembering to subtract the background from your observed sample count until there seems to be no appreciable change in the count rate or until the rate falls to near zero.
6. Repeat your observations with the copper, aluminum, and lead foils and the beta source.
7. Repeat your observations using the gamma source in the place of the beta. Note the change in the way absorption takes place with the materials of different atomic weight.
8. Graph your results for all the absorbers and the two sources.

Discussion:

Can you explain the difference between the absorbing qualities of the different materials?

Can you explain the difference in absorption between the two sources?

If you plan to plot your absorber thickness on the same graph paper, you will need to calculate the absorber on the basis of milligrams per square centimeters.

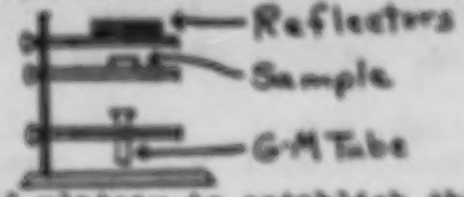
Purpose: To study the effect of backscatter

Equipment: G-M end window tube and scaler

Material:
30 or 40 2" squares of 1/32" cardboard
10 or 20 2" squares of copper foil
10 or 20 2" squares of aluminum foil
10 or 20 2" squares of lead foil
Beta radioactive source

Procedure:

1. Set up the G-M tube and scaler as indicated in the diagram



2. Use the predetermined plateau to establish the operating voltage of your counter.

3. Determine the background count for the geometry of the system. (Background = count rate without sample present. Geometry = relationship of counter to the sample.)

4. Determine the count rate for the radioactive source without any reflectors present.

5. Record your observations as you add each cardboard reflector. (Remember to substract the background).

6. Plot your observations of count rate on the Y-axis and the absorber thickness on the X-axis.

7. Continue to count for each absorber added until there seems to be no appreciable change in the counting rate.

8. Repeat the experiment using the copper, aluminim, and lead reflectors.

Discussion:

If you wish to plot your reflector thicknesses on the same graph paper, you need to calculate the thickness in milligrams per square centimeter.

Relationships between atomic size and reflection should become apparent in this experiment.

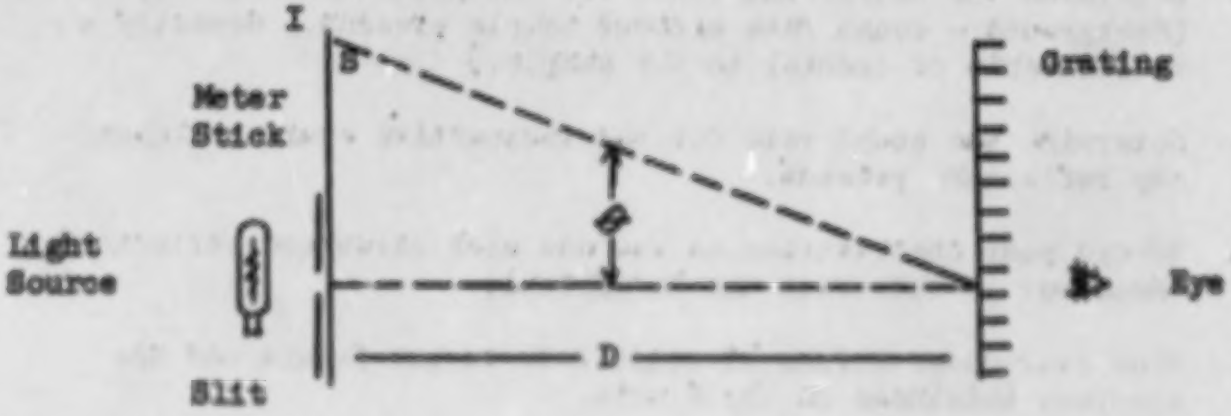
The infinite thickness of a reflector can be calculated.

THE DIFFRACTION GRATING

PURPOSE: The purpose of this experiment is to acquaint you with a diffraction grating. Reflection and transmission gratings are widely used in optical instruments to assist in producing spectra and in measuring wave lengths. Each of you will have observed the spectra produced by reflection and transmission gratings and probably will have determined the wave lengths of several lines of some spectral source by the time this experiment has been completed.

NOTE: The gratings are replicas on thin plastic film. Please arrange both the reflection and refraction gratings by contacting the supporting wooden ring. REFRAIN FROM TOUCHING THE GRATING SURFACE.

APPARATUS:	Light Source	Reflection Grating
	Mounted Slit	Transmission Grating
	Mounted Lens	



PROCEDURE: Arrange the source, slit and transmission grating so that these items have a common axis; the slit should be relatively near the source, and D should be greater than 1 meter. (1-1/2 meters is a good separation to use with the gratings available to you).

Light from the source falling on the slit passes through the grating. The observer can see the virtual diffraction pattern by placing his eye at E and observing the parallel rays which leave the grating at angle θ and thus appear to come from I. The position of I on the meter stick S can be observed by looking over or through the grating.

Record (to the nearest 0.1 cm) the position of the center of several line images in the first-order pattern. Repeat several times for each line studied; do this on each side of the slit. Obtain the average value of theta for each of the spectral lines you studied.

Now employ the grating equation $n\lambda = d \sin \theta$ to make your determination of the wave length of each line for which you obtained data. The d in this equation is the distance between two successive transparent spaces called the grating spaces. (d = lines/inch)

SUGGESTIONS FOR FURTHER STUDY:

1. See whether the lens can be used on the side of the grating where the eye is located to "project" an image of the diffracted lines onto a screen placed beyond the eye, to the right in the sketch above.
2. Place the reflection grating in the light from the source to see whether spectra can be observed.
3. Read what your physics text says about diffraction gratings and see what appears in available college physics texts regarding the subject.

PURPOSE: To demonstrate the materials presented in chlorophyll

MATERIALS:
Whatman No. 1 filter paper
Spinach leaf
White sand
Mortar and pestle
Capillary dropper
Beaker
Ethyl ether
Petroleum ether 30-60
Acetone
Benzene
Medical museum jar with lid

PROCEDURE: Prepare a separatory solvent for the chromatographic jar (medical museum jar) by placing 1 part benzene, 5 parts acetone, 45 parts petroleum ether 30-60, and 34 parts of ethyl ether in the bottom of the museum jar. Put enough solution in the bottom of the jar so that it is covered to the depth of one inch.

Place the spinach leaf, acetone, and sand in a mortar and pestle. Grind the leaf to extract the chlorophyll with the acetone. Decant the acetone-chlorophyll solution from the sand and leaf remains into a clean beaker.

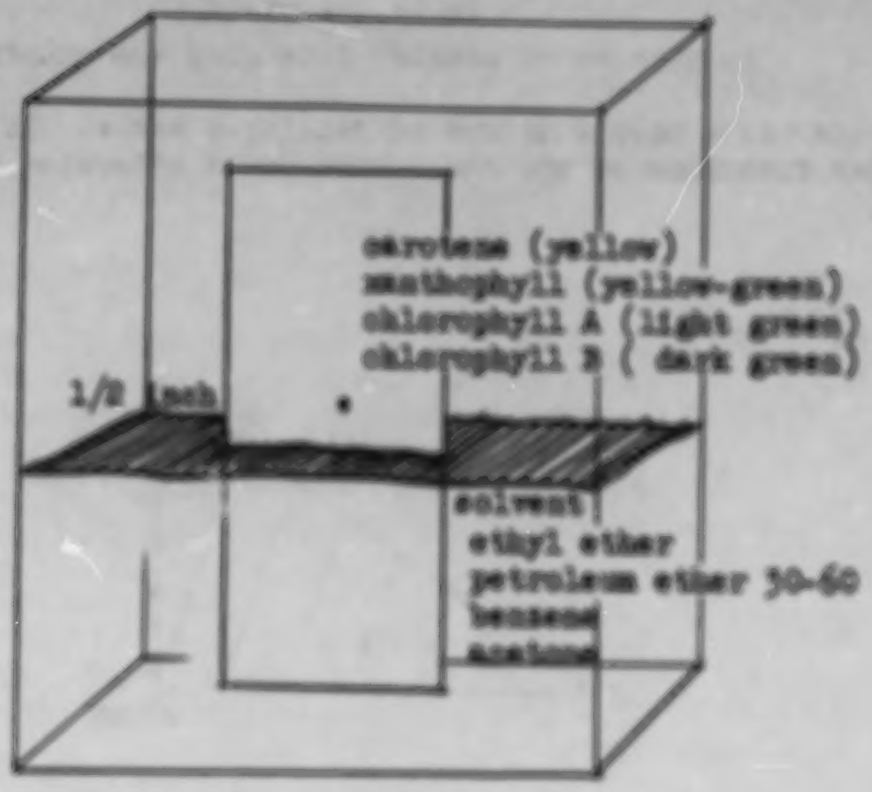
Permit the acetone to evaporate completely. Add now a little acetone so that the chlorophyll-acetone solution is as concentrated as possible.

With the aid of a capillary dropper, spot the filter paper about 1/2 inch above the level of the solvent when the paper is hung in the solvent of the jar. Wait for the acetone to evaporate from the chlorophyll spotted paper before hanging the paper in the chromatographic jar (medical museum jar.)

Within 30 minutes, a definite separation should have been about completed. There should be four distinct layers. From the bottom up on the filter paper, you will find first, chlorophyll B (dark green), chlorophyll a (light green), xanthophyll (yellow-green) and carotene (yellow).

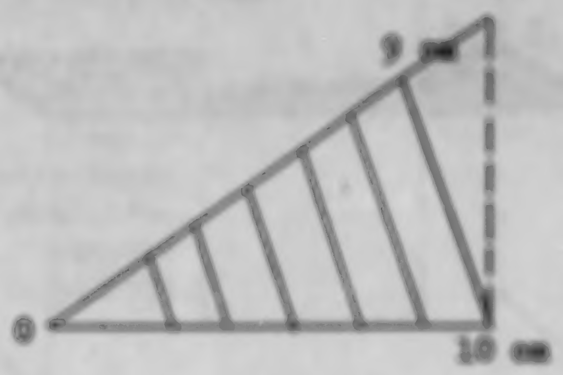
When separation is complete, remove the chromatograms from the jar and permit them to dry. The four extracts from the spinach leaf may be cut apart. Further work can then be done on the material from the interest of of the instructor and the student.

A variation in identification is the use of an ultraviolet light to identify the materials of the leaf.


carotene (yellow)
xanthophyll (yellow-green)
chlorophyll A (light green)
chlorophyll B (dark green)
1/2 inch
solvent
ethyl ether
petroleum ether 30-60
benzene
acetone

Making a Vernier
(a problem of similar triangles and proportion)

A vernier is a simple method of reading a scale. It aids in reading smaller fractions of the scale that would otherwise be difficult to read.



Each triangle becomes a similar triangle and therefore the divisions on one side of the triangle are proportional to the division on the other side.

Purpose: To study the operation of the G-M tube and scaler

Equipment: G-M tube and scaler

Materials: Planchet, ringstand and clamp, radioactive source

Procedure:

1. Turn the scaler, on being sure to keep the voltage as low on the scaler as possible. (Some scalers have an independent high voltage adjustment.)
2. Check the counter on a test circuit first if the counter is so equipped.
3. When the sixty cycle test is recording regularly, turn the selector switch to manual and prepare for counting a sample as follows.
4. Place the radioactive sample approximately one inch from the G-M tube window.
5. Adjust the high voltage until the tube begins to count. (If the counting proceeds too rapidly, move the sample away from the G-M tube. 10,000 counts per minute is a good count rate.
6. Back the high voltage down just below the point at which it begins counting (threshold voltage) and then advance the voltage at regular step intervals.
7. Record the count rate with each voltage step.
8. Plot the count rate on the Y-axis and the voltage on the X-axis.

WARNING: DO NOT PERMIT the G-M scaler to give too rapid a count at any time!

DO NOT ADVANCE the high voltages beyond a sudden increase in the count rate!

Discussion:

The plateau will indicate the age and condition of the G-M tube. As the gases in the tube are used, the plateau will become shorter and the slope steeper.

Halogen filled G-M tubes usually show a "knee" between the threshold and operating voltage on the plateau.

Most of the quantitative counting in the use of a G-M tube should be about 10% above the threshold voltage.

Any electronic device will last longer if the voltage is not turned on and off. If it is practical to leave the scaler turned on throughout the day or period it will be used, then leave the instrument on.

GERMINATION EXPERIMENTS

Hypotheses to be tested

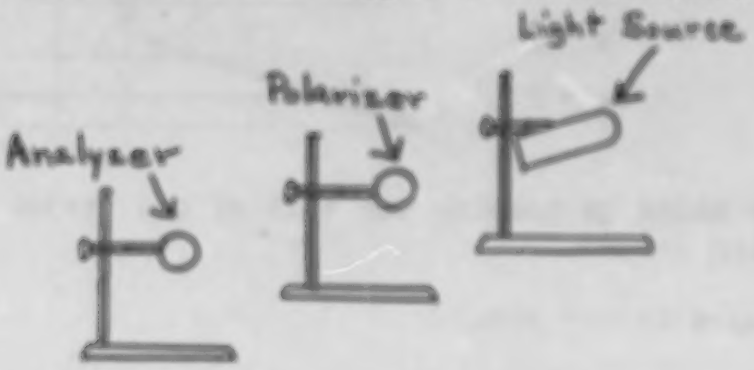
1. Light is necessary for the germination of seeds.
2. During the germination process, digestion of stored food takes place.
3. Seedling plants will not develop chlorophyll in darkness.
4. Seeds must have air (oxygen) for the process of respiration while germinating.
5. Seeds use energy and produce carbon dioxide during germination.
6. Some parts of the embryo plant respond to gravity during germination.

Purpose: To study some explanations of the polarization of light

Equipment: Light source with collimating lens
2 glass plates mounted on a wooden table
2 polaroid gelatin filters enclosed in glass

Procedure:

1. Set up the equipment as suggested in the sketch.



2. Determine the plane of polarization at A from reflection and at B from refraction.

3. Determine the angle of reflection necessary to produce polarization at A.

4. Place a polished aluminum or stainless steel mirror instead of the glass plate in the holder. Analyze the reflected beam as before.

Discussion:

Explain polarization by vectors and diagrams.

Explain your findings on the reflected beam from metallic surfaces.

Vector Analysis

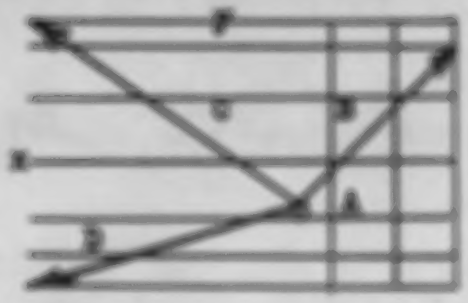
Solve the following problem by the use of vectors:

$A_x = 2$ $A_y = 0$

$B_x = 3$ $B_y = 3$

$C_x = 4$ $C_y = 4$

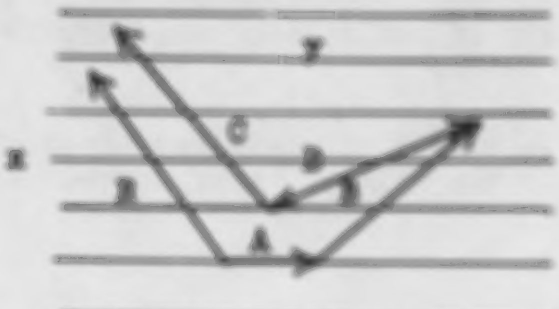
$D_x = 4$ $D_y = 2$



1. Vectors can be added by placing the tail of one vector on the head of the preceding vector.

2. They can be added in any order.

3. Vectors can be moved so long as the magnitude and direction remain the same



$R_x = -3$ $R_y = 5$

4. By the Pythagorean Theorem or by the distance formula from analytical geometry.

$$R = \sqrt{R_x^2 + R_y^2}$$

$$R = \sqrt{9 + 25}$$

$$R = \sqrt{34} \qquad R = 5.83$$

5. From analythical geometry we cán develop the equation for the line. The equations can then be solved simultaneously.

Purpose: To study some of the properties of magnetism

Materials:
- Hydrometer jar 12" high and lid
- Tecnifax paper
- Ammonium hydroxide (concentrated)
- Ultra-violet light (flourescent tube type)
- 2 bar magnets
- iron filings

Procedure:

Place the bar magnet on a table so that their fields will interact appreciably (the poles should be about 1 inch apart.)

Place the Tecnifax paper on top of the bar magnets and sprinkle the iron filings on top of the paper.

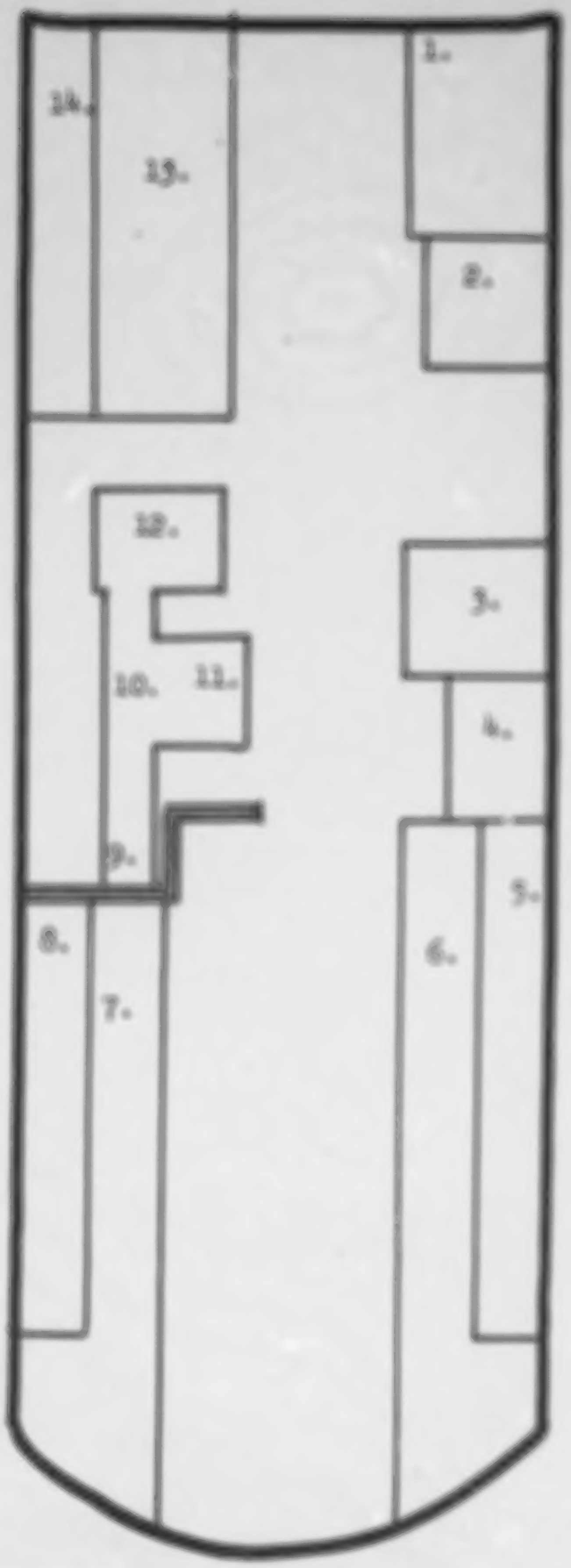
Tap the paper gently to arrange the iron filings and expose for several minutes to the ultra-violet light.

Place the Tecnifax paper in ammonia fumes (not the liquid) which are in the hydrometer jar. Remove the paper when sufficient development has taken place.

APPENDIX E

PLAN OF MOBILE LABORATORY.

Plan of the Mobile Laboratory



1. Tape Recorder with Storage Cabinet
2. Electronic Controls
3. Electronic Controls
4. Power Control and Rack
5. Storage Cabinet Above
6. Counter Space with Storage Cabinets Below
7. Counter Space with Storage Cabinets Below
8. Storage Cabinet Above
9. Projection Television Camera
10. Optical Switching Device
11. Motion Picture Projector
12. Slide Projector
13. Television Control Console
14. Storage Cabinets Above

Scale: 3/8" = 1'